HISTORY

OF THE

PROGRESS

AND

PRESENT STATE

OF

ANIMAL CHEMISTRY.

BY

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IN THREE VOLUMES.

VOL. I.

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PREFACE.

IT was the precept of an eminent philofopher, that he who undertakes to extend the limits of a fcience fhould previoufly be made acquainted with the difcoveries of his predeceffors. To facilitate the application of this precept, firft induced the Author to make the following compilation.

That all organized bodies are compofed of ultimate or remote parts, will not be denied, but there feems to be a prevalent idea, that it is neceffary for thefe component parts to be in certain proportions or peculiar combinations, in order to eftablifh the equilibrium of health; and that when thefe are deftroyed, difeafe is the confequence, which cannot be cured until the organic machine receives thofe parts which are deficient, or gives up thofe which are in excefs, fo that the proper proportions be again effected, and the equilibrium of health reftored. If fuch be the cafe, the conclufion is, that the happinefs or mifery of individuals depends ultimately on the proportion of the different parts of the fubftances that compofe them.

The human intellect appears to delight in fpeculation; for the idea has been extended fo far as to fuppofe, that fince the mind is only the production of external objects acting on vital organization, conveyed by fenfes, all of which are compofed of ultimate parts; this nobler part of our nature muft likewife be within the reach of the powers of the analytical fcience, and that fome diftant and future age may be indebted for an explanation not only of the functions of the body, but of the faculties of the mind, to chemical analyfis.

At prefent, there are not a fufficient number of facts to warrant a conclufion, that thefe fpeculative opinions can ever be verified, although, from the difcoveries chemiftry

has already made, and the vaſt extent of it's capacity for future inveſtigation, it perhaps would not be a juſt way of reaſoning to aſſert the impoſſibility: who could have believed, thirty years ago, that either fixed air or water was capable of decompoſition, that the diamond was nothing but charcoal, and that fleſh might be converted into ſpermaceti? Yet this ſcience is only in it's infancy, whilſt it's progreſs is deemed to be eternal.

Every attempt is laudable in the cauſe of humanity, although it ſhould be fruitleſs, and the chemical phyſiologiſt need not be informed of the great importance it would be to medical ſcience to bring theſe opinions to the teſt of experiment, to prove or refute them, and to aſcertain whether the deficit and ſurplus in the proportions of the remote parts of organic bodies are not rather to be numbered amongſt the *effects* than the *cauſes* of diſeaſes.

The phyſiologiſt who undertakes ſuch an inveſtigation, need not be diſcouraged at the quickſands of former times into which ſo many have fallen; he will find that the preſent ſtate of chemiſtry is different from what it was at that unfortunate period, when the extravagancies it introduced into medicine made the alliance dangerous. Modern chemiſtry has already thrown great light on ſeveral parts of the animal ſyſtem; it has within theſe laſt few years commenced an inveſtigation of ſeveral of the functions of the body, and explained the manner in which they are carried on with ſome degree of ſucceſs: the proceſſes of reſpiration, of perſpiration, of digeſtion, of animalization, and the action of oxygen upon vital organization, no longer remain in that ſtate of total darkneſs in which they were ſo lately enveloped, whilſt the proficiency already attained in this department of the ſcience, has eſtabliſhed the animal analyſis upon ſo firm and broad a baſis, as to promiſe in future the happieſt reſults. Other functions remain to be inveſtigated, ſuch as ſanguification, oſſification, nutrition, and the ſecretion of the dif-

ferent fluids; to which may be added the action of thofe powers that produce difeafes, and that of medicines on the animal body; but it is by purfuing the fame method of analytical reafoning that their operations are to be explained, and their nature thoroughly underftood. Every preparation is already made for this grand work, and there is reafon to believe, that the route which has hitherto been explored will conduct the philofopher to a more precife and exact knowledge of the phenomena of the animal economy, and to the formation of a more perfect theory of the laws that govern the vital and mental world.

What has been faid of the medical fcience may be extended to the arts. Several of thefe, it is well known, are indebted to the animal kingdom for their refpective materials; and the enlightened artift need not be informed of the great defideratum of having the nature and properties of the materials he employs thoroughly invefti-gated by chemical analyfis; it is, perhaps, the only means by which his art can be reduced to fcientific principles, by which his operations can be fimplified, his proceffes accelerated, and his labours fhortened. It is to this fcience that the arts of dyeing, tanning, making of glue, of hats, of cutlery, the operations of cookery, the proceffes of the dairy, &c., have been brought to their prefent ftate of perfection, and it is to the fame fource they can only look for future improvement.

For fuch an undertaking, a material advantage, however, feemed to be wanting: a compilation in which the enterprifing experimentalift could be made acquainted with the facts and obfervations of thofe who had preceded him. It is true, feveral learned foreign chemifts have attempted to fupply this deficiency, and Gren, Hildebrandt, Jacquin, and de la Grange, have publifhed compilations on the fubject; but their plans appear to have been too limited, and their defcriptions too concife; many of the phenomena recorded in the analyfis of ani-

mal fubftances have been excluded, fome of the moft interefting particulars have been forgotten. In the work now prefented to the public, a different plan has been purfued, a more enlarged fcale has been attempted, and an endeavour has been made to give the whole a more connected and fyftematic arrangement. For thefe purpofes, the Author is principally indebted for his information to the Elementa Phyfiologiæ of Haller, the Encyclopédie Méthodique of Morveau and Fourcroy, and to Leonhardi's German tranflation of Macquer's Chemical Dictionary, with the excellent additions. At the fame time, copious extracts have been occasonally felected from more recent publications, particularly thofe collections of different learned focieties, to whofe diligence and induftry chemiftry prefents her choiceft ftore. From the former, the early hiftorical part has been chiefly taken; from the latter, the ftate of analyfis of the prefent day. With fuch affiftance, it is to be hoped, the deficiencies of former compilers may have been in fome meafure fupplied, and the knowledge they have collected increafed, by having had accefs to a more extenfive mafs of materials, and to later difcoveries.

Derby, Dec. 1ft, 1802.

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THE

HISTORY

OF

ANIMAL CHEMISTRY.

ANIMAL SUBSTANCES.

MAN in confequence of fuperiour organization, when compared with all other vital organized beings, has claimed the diftinctive mark of placing himfelf at the head, and of forming a clafs peculiar to his own fpecies, and almoft all naturalifts, fince the time of Ariftotle, have approved of the decifion: the remaining part of the animal creation which fo far exceeds him in number, has been divided by Daubenton, the French natural hiftorian, into eight claffes, viz. Quadrupeds, Cetacea, Birds, oviparous Quadrupeds, Serpents, Fifh, Infects, and Worms. Of thefe claffes, very few have, at prefent, been fubmitted to chemical inveftigation; it is principally to the human fubject, and the oviparous quadruped, that the refearches of the analytical fcience extend, although fome flight attention has been paid to the oviparous quadrupeds, infects, and worms. Animals.

Confist of different parts.

Animals, it is well known, consist of a variety of different parts, such as blood, flesh or muscle, membrane, tendon, ligament, fat, nerve, periosteum, brain, cartilage or gristle, bone, hoof, horn, ivory, shell, hair, and feathers, together with other substances that give rise to their colour, smell, and taste. All these parts, as well as the secretions of different kinds, are formed from the blood by various processes of the organized machine, from the nutriment received into the stomach; and by the same means these parts are constantly supported during the life of the particular animal. Whilst this formation and renewal are going on, other matters are separated, such as urine, sweat, and feces, which are excreted and evacuated from the living machine, in the form of useless excrement.

On taking a general view of all these parts and matters, as far as they have been submitted to any chemical analysis, they may be divided into

Division of animal substances.

1. Fluids,	5. Oils,	9. Colouring Matter,
2. Solids,	6. Acids,	10. Concretions,
3. Hard Parts,	7. Poisons,	and
4. External Parts,	8. Aromatics,	11. Excrements.

Since the formation of these substances is for the most part derived originally from vegetables, and the manner of their conversion has not yet been ascertained, it is supposed that an exact chemical analysis of these parts, and a comparison of their component principles with those of vegetables, may be a means of casting some light upon the operations and nature of the different functions, and lead to a more exact knowledge of the laws of the animal œconomy.

Imperfect state of it.

Animal Analysis.—The analysis of animal substances is the most difficult and least advanced of any part of chemistry. This neglect has been attributed to several causes, viz.—To the disagreeable products that arise on

submitting them to experiment, which have been found sufficient to repress the ardour of inquiry; the great want of proper means and methods to treat them; the impossibility of reproducing these matters, or the total absence of every idea of synthesis; and lastly, the small degree of interest which the chemist who was not a professed physician took in the results of their analysis. Such have been the principal circumstances that have arrested the progress of this part of the science. The causes.

It was owing to these causes that the old chemists contented themselves with the mere distillation of animal matters in the open fire; an operation which, it is now well known, entirely changes their nature and composition. It is to this science, therefore, when it put on a more modern and philosophic form, that we are to look back for the first traces of a more judicious method of analyzing these substances; and we are indebted to Margraaf, Rouelle, Proust, Macquer, Scheele, and Bergmann, for offering us a more extensive view, and a deeper insight into the principles that compose them. Antient method of analysis.

The advantages, likewise, which a knowledge of the different gases presented to the chemist, and that flow of light which the new French chemical revolution had expanded over a variety of phenomena hitherto obscurely explained, or totally overwhelmed in darkness, enabled the chemist to pursue a different rout from what had been before attempted; and for the present appearance of animal analysis, although still in a very imperfect state, we must have recourse to the indefatigable industry, and the numerous and well conducted experiments of Fourcroy, Marqueron, Vauquelin, Parmentier, Deyeux, Stipriaan, Berthollet, Pearson, Wollaston, and Haggitt. New method.

Forsaking, or at least not relying upon, the decomposition of animal substances by fire alone, according to

the old method, later chemiſts have tried the effects which thoſe chemical agents have upon them, which are known by the name of reagents, ſuch as the different acids, alkalis, alcohol, &c.; and they have been ſubmitted to the ſame operations as chemiſtry had made uſe of in the analyſis of other bodies, ſuch as ſeparation by repoſe, expreſſion, decantation, and filtration, either of thoſe fluids which are found mixed together, or contained in various parts of the more ſolid and hard animal matter. The action they have on the colouring parts has been likewiſe obſerved with great care, the different changes they undergo at different temperatures, the animal fluids have been evaporated, and the different ſalts they contain have been carefully extracted from them, without undergoing any alteration. By purſuing theſe methods of analyſis, the above chemiſts have made ſome very important diſcoveries in the animal kingdom, the component parts of ſome of it's matters have been expoſed, a difference has been found between animal and vegetable ſubſtances, and we are enabled to reduce them to ſome ſyſtematic arrangement.

It is by the new method of analyzing that almoſt every diſcovery has been made in animal ſubſtances, and to it we muſt have recourſe in the proſecution of further inquiries, in order to acquire a complete knowledge of their properties and compoſition.

Two kinds of analyſis.

On taking a general view of the action of chemical agents on animal ſubſtances, the means by which their analyſis and decompoſition are affected are either natural or artificial. The firſt comprehends their analyſis by putrefaction; the ſecond, by heat and by chemical reagents. The products which ultimately ariſe, and the new combinations that take place, are, generally ſpeaking, very ſimilar, and the principal difference between them is

perhaps more to be attributed to their flower or quicker decompofition, than to any intervening new fpecies of matter.

1. By Putrefaction, or their fpontaneous decompofition, *vide* Putrefaction. Natural.

1. By Heat. The action of heat either accelerates their decompofition alone, or when combined with other powers, giving rife to new combinations. The gentle heat of diftillation firft fends over an aqueous portion from an animal fubftance, with it's peculiar aroma. On increafing the heat gradually, an empyreumatic oil arifes, at firft more or lefs yellow, at laft more or lefs black, according to the degree of heat; then follows volatile alkali in it's liquid or dry ftate; and when the heat is red or exceffive, the aerial fluids are obtained, fuch as fixed air, hydrogen gas, and a little pure air. The remaining portion is a black coal of difficult incineration, which on being lixiviated afterward, affords falts, fuch as the phofphats of lime and foda. During this procefs, the animal matters undergo a total decompofition, and the greater part of the products appear to be new combinations which did not previoufly exift in the matters, but are formed by the different unions of their component principles. Of the manner however in which thefe take place there are feveral opinions. According to the phlogiftic fyftem, the elements of animal fubftances are for the moft part pure air, phlogifton, calcareous earth and water; when therefore a diftilling heat is applied, the *air* and *water* yield firft to the expanfive force of the fire, and confequently the firft products are principally compofed of thofe two elements; by a greater degree of fire, the phlogifton is feparated from the earthy matters, and with a certain proportion of air, water, and earth, forms *oil*; the *volatile alkali* arifes from the compofition of another part of the phlogifton, and from as much of it as can be

Artificial.

According to the old fyftem.

united with water by means of a little of the earth and air. *The acid liquors* are produced from another portion of the air with the organic elements, whilſt the *fixed air* only differs from the latter by it's air being combined with a leſs proportion of them; in the *inflammable gas* there is leſs air and more phlogiſton, it's being of the heavy kind ariſes from oily matter being diſſolved in it; the remaining charcoal conſiſts of the reſt of the phlogiſton, united with the greateſt part of the earth; and finally, the phoſphorus was ſtill to be accounted for, although it was conſidered as a compound ſubſtance.

According to the new ſyſtem.

According to the antiphlogiſtic doctrine, the origin of theſe products is explained in a different manner. Lavoiſier appears to have entertained two opinions reſpecting their formation, one of which he afterward abandoned, but as it was only the prelude to a more ſatisfactory method of explanation, it will be neceſſary to mention it. Berthollet and Fourcroy, and the other French chemiſts, were of the ſame opinion. Animal ſubſtances they aſſert contain neither water, carbonic acid gas, nor empyreumatic oil already formed in their compoſition, but only their elements; a degree of heat a little above boiling water is ſufficient to unite the hydrogen with the oxygen, and form water, and the hydrogen and carbon to form oil, whilſt the azot and hydrogen produce the volatile alkali. In theſe ſubſtances, as well as in vegetables, the carbon, Lavoiſier aſſerts, is in exceſs, which is the principal cauſe perhaps of their action on water; the carbon in exceſs attracts the oxygen of the water and forms carbonic acid gas, whilſt a portion of the hydrogen becoming free, is diſengaged, or combines with the carbon to form oil, or with azot, and forms ammonia.

Afterward Lavoiſier formed a new theory. He aſſerts, that three of the principles, viz. hydrogen and oxygen

and azot, have a great tendency to unite with the matter of heat, and take the form of gas, whilſt the carbon is a fixed principle, and has very little affinity with the matter of heat, particularly when united with phoſphoric acid. If the temperature to which the ſubſtance is expoſed in diſtillation does not much exceed that of boiling water, the hydrogen and oxygen unite to form water, which paſſes over into the receiver. A portion of the hydrogen and of the carbon alſo unite and form the empyreumatic oil, which is more or leſs dark coloured, according to its quantity of carbon, whilſt another part of the hydrogen unites with the azot and forms the ammonia.

But if inſtead of a heat nearly equal to boiling water, a red heat be applied to an animal ſubſtance, water is no longer formed, or that water, if generated by the firſt effect of the heat, is decompoſed, the oxygen unites with the carbon to which it has a greater affinity at this degree of heat, and forms carbonic acid gas, and the hydrogen being diſengaged either unites with the azot to form ammonia, or part of it uniting with the matter of heat eſcapes in the form of hydrogen gas. At this degree of heat no oil is formed, or if formed would ſoon be decompoſed. The phoſphorus remaining combined with the carbon renders it fixed and difficult of incineration. Such are the general products and explanation of the decompoſition of animal ſubſtances by heat.

We are however informed of other products having been found during this proceſs of diſtillation, thus Berthollet found a peculiar acid, viz. the zoonic, and when animal ſubſtances have been ſubmitted to a very ſtrong degree of heat, it gives riſe to the formation of the pruſſic acid, and even phoſphorus.

2. By reagents.

The blue colours of vegetables are changed to a green by the principal fluids of animals, from their containing

ſoda. Water by the aid of heat extracts the gelatin and coagulates the albumen of animal matters, whilſt the fibrin remains behind. The principle of tan precipitates the gelatin. Acids when diluted coagulate the albuminous part; unite with the ſoda, with which they form a neutral ſalt; diſengage the lime by decompoſing the phoſphat of that earth, and form with it an earthy ſalt according to the nature of the acid employed. They likewiſe unite with the oily parts. If the *ſulphuric* acid be uſed, the ſubſtance becomes blackiſh; if the nitrous, it takes a yellowiſh hue; and if the latter acid be aſſiſted by a ſlight elevation of temperature, it is ſufficient even in it's weakeſt ſtate to diſengage the azot in the form of gas. When in their concentrated ſtate the acids decompoſe animal ſubſtances by their corroding or cauſtic property, and during this action new compounds are formed.

The *ſulphuric* acid attracts their aqueous part, or if this be in ſmall quantity, a ſeparation of their principles takes place, the azot unites with a portion of hydrogen, and forming volatile alkali combines with the ſulphuric acid, or with a vegetable acid, which according to Vauquelin and Fourcroy is a new production, whilſt another part of the hydrogen forms with the oxygen that water which is requiſite to ſaturate the ſulphuric acid; at the ſame time the quantity of carbon, which exceeds that required with the hydrogen and oxygen to compoſe the new acid, remains in the form of a black coal, or if the ſubſtance be in a liquid ſtate, in the form of flocks or black powder. During this proceſs there is no evident eſcape of any volatile principle.

The action of *nitric acid* on animal ſubſtances is firſt to diſengage the azot gas from them, they become yellow, and there ariſes on their ſurface a kind of cryſtallizable, inflammable, and bitter varniſh; at the ſame time there is an adipoſe ſubſtance formed, which ſwims on the top

when the mixture is become liquid, the carbonic and pruſſic acids ariſe in the form of elaſtic fluids, ammonia is produced which ſaturates the nitrous acid in part, and the ſubſtances thus reduced to a vegetable ſtate are found in the portion which remains fixed and liquified with the nitric acid, converted into oxalic acid, and ſometimes into the mucous and acetous acids. Another portion of the animal ſubſtance forms water, which is either reduced to a vapour or dilutes the ſalts and acids. In this account of animal decompoſition by the nitric acid, each ſubſtance is diſtinguiſhed and characterized by different reſults; one affords a great deal of azot gas, little ammonia, and much yellow and fat matter; another gives little fat, and an abundance of vegetable acids; a third a deal of pruſſic acid; in a fourth the mucous or ſaccholactic acid formed is very abundant, whilſt others do not even ſhow a ſingle trace of it. Some likewiſe diſengage a great deal of carbonic acid gas, others decompoſe a great quantity of nitrous acid during their decompoſition; whilſt others, on the contrary, ſuffer their bond of compoſition to be diſſolved on the leaſt contact of a ſmall proportion of this acid. It is by theſe differences that the expert chemiſt may judge of thoſe which characterize the different animal matters.

The *muriatic acid* when combined with heat and applied to animal ſubſtances diſengages the azot and hydrogen forming ammonia, which by uniting with the muriatic acid gives muriat of ammonia, and hydrogen gas is likewiſe extricated towards the end of the proceſs.

Neither the ſulphuric nor muriatic acid acts with ſuch energy on animal ſubſtances as the nitric acid ſufficiently concentrated; and the reaſon why azot gas is extricated in the latter caſe, whilſt it unites with hydrogen in the form of ammonia in the former two, is conjectured to ariſe from the neceſſity of heat, ſo that the azot is in ſimilar circum-

ſtances as when the animal ſubſtance is diſtilled, in which it combines with the hydrogen; one part of the hydrogen is obliged to take an elaſtic ſtate.

It is neceſſary to obſerve, that with the ſulphuric acid very little carbon remains, but a large quantity of carbonic acid gas is obtained; whilſt with the muriatic acid, ſince there remains a much larger proportion of carbon, it is to be preſumed that very little carbonic acid gas is diſengaged.

Alkalis, when in their mild ſtate, unite with animal acids, forming with them peculiar neutral ſalts. When in their cauſtic ſtate, Berthollet affirms, they diſſolve animal ſubſtances, by which their cauſticity is taken away; but according to Fourcroy, the diſagreeable putrid odour which Berthollet obſerved proves that ſomething elſe takes place beſides a ſimple combination. He therefore concludes, that when animal matters are put into a ſtrong cauſtic alcaline ley, ammonia and caloric are both diſengaged; that in proportion as this ammonia is formed the animal matter loſing thereby five times a greater quantity of azot than of hydrogen, contains in union with the alkali much more hydrogen than before, and thus contracting an oily character, it's alkaline combination is a real ſoap. Acids decompoſe it and ſeparate a concrete brown oil from it, whilſt earthy and metallic ſolutions form earthy and metallic ſaponaceous precipitations.

Lime, barytes, and ſtrontian earth act in the ſame way, but with leſs energy.

The calces of metals and metallic ſalts are likewiſe powerful cauſtics, but their action conſiſts in parting with their oxygen and forming a combuſtion, for which, vide *Cauſtics*.

Alcohol precipitates the albumen in the form of a coagulum and extracts their reſinous parts. Animal ſubſtances, when reduced to ſuch a ſtate as only to have their

faline and earthy parts left, are finally examined like other faline and earthy bodies, which it is perhaps unneceffary to mention in their general analyfis.

Encyclopedie Méthodique, article *Analyfe*.—Berthollet fur la nature des fubftances animales, Mém. de l'Acad. royale, an. 1784.—Ker's Dictionary of Chemiftry, 1 Part p. 186, 194, 195, Birmingham, 1789.—Lavoifier, Réflexions fur la décompofition de l'eau par les fubftances végétales et animales, Mém. de l'Acad. p. 540, an. 1786. —Of the fpontaneous action of concentrated fulphuric acid on vegetable and animal fubftances, by Cit. Fourcroy and Vauquelin. Nicholfon's journal, No. 9. p. 272. Jan. 1786.—Précis d'obfervations fur l'analyfe animale comparée à l'analyfe végétale, par M. Berthollet. Journal des Scavans, T. 28. p. 272. Jan. 1786.

FLUIDS.

In giving an account of the different parts of the animal body, it might perhaps appear more fyftematic to defcribe them according to the priority of their formation; but this can only be done with refpect to a few. Thus it may be faid, that the fluids are formed before the folids; the folids before the hard parts; and the laft before the external parts; but it would be difficult to proceed further without much uncertainty: this rule, however, ought to be obferved as nearly as poffible. The various ufeful fluids of the animal body appear to be much lefs in quantity than the folids; and although Gaubius, as well as Cullen, was of opinion that they are formed from the folids, modern authors have reverfed the doctrine, and have defended the old fyftem of Harvey, by afferting, it is from the fluid blood that all the remaining fluids, as well as folids, derive their origin. The ufeful fluids which have been fubmitted to chemical analyfis,

may be divided into eggs, the blood, and its different fecretions.

Eggs. *Eggs.*—It is in the egg that we muft look for the commencement of vital organization; but little is known of its developement, or the progrefs which the embryo makes as it verges towards perfection. Eggs may be diftinguifhed into two different kinds. 1. Thofe defended by a hard external covering, called the fhell, as the eggs of birds. 2. Thofe which are only provided with a tough membranous covering, as the eggs of different fnakes, and fome of the oviparous quadrupeds.

The eggs of birds, which are the only kinds that have undergone any chemical inveftigation, are compofed of four parts, viz. 1. A bony fhell. 2. A membranous pellicle. 3. The white; and 4. the yolk. With refpect to the 1. and 2. they will be mentioned amongft the hard and folid parts.

The White. Neumann. *The white or albuminous part.* This part of the egg is a thickifh, tranfparent, adhefive, vifcid fluid. Neumann ranked it among the gelatinous fubftances, as poffeffing their vifcid and glutinous quality, but although like the gelatins it is capable of being ufed as a cement for glafs and earthen ware, he thought it differed very materially from the other fubftances of that kind, at leaft from thofe extracted from the folid parts of animals, in being not foluble but hardened in boiling water. This coagulation by heat is fince found to be one of the diftinguifhing characters of the white of the egg, by which it forms with feveral other animal matters, particularly the ferum of the blood, a diftinct genus, for which, vide *albumen.*

Properties of the white. The white of the egg changes the fyrup of violets green from its difengaged foda. It is foluble in cold water, although it does not eafily mix with it, on account of its vifcidity; thus 10 parts of water diffolve exactly one part of white, and acids and alcohol precipitate it again

in the form of coagula, as in milk. With aerated water the ſolution is imperfect, and the white from being perfectly tranſparent forms a few white ſtreaks, or becomes turbid, according to the quantity of air contained in the water.

Water when heated coagulates the white, before it comes to the boiling point; according to Fourcroy this takes place at 150°, but according to Leonhardi at 160° of Fahr[t]. In this ſtate it has loſt it's tranſparency, is of a milk colour, and is now entitled to the name of white of egg with great propriety; it is alſo found to be more or leſs hard according to the degree of heat applied; thus it is harder when boiled in ſalt than in freſh water, and ſtill more ſo in oils. It has alſo loſt ſome of its weight, for Hoffmann informs us that a hen's egg of 2 oz. 1 drachm (*i. e.* ſhell little more than 1 drachm; yolk $\frac{1}{2}$ oz. and white 1 $\frac{1}{2}$ oz.) on being hard boiled loſt 1$\frac{1}{2}$ drachm, whilſt Neumann found that 6 drachms 25 grains of this coagulated white afforded, on being exſiccated, only 55 grains.

Although pure albumen is not ſoluble in boiling water, yet according to Fourcroy the proportion of water diminiſhes the tendency of the white to coagulation or ſolidity, by preventing the near approach of the particles; thus if it be beaten with about one half it's weight of water and then boiled, a much leſs hard maſs is obtained than if none had been uſed; and he affirms with Scheele, that if the quantity of water be greater, as for inſtance, if it be mixed with 10 parts, it is even ſoluble in boiling water, in which the combination reſembles ſkimmed milk or butter milk, a fluid formed for the moſt part of water and albumen in a particular ſtate, acids added coagulate it again as in milk. When eggs are freſh laid they are not ſo eaſily coagulated as others. White of the egg when left to itſelf, and expoſed to a moiſt warm air,

very foon becomes thinner and thinner until it is putrid: it then refembles urine in fmell.

The white on being expofed, a few days during fummer, to the fun, Neumann found was converted into a dry and hard mafs refembling in confiftence and tranfparency yellowifh gum arabic, and when fmeared on a piece of paper or other fubftance by means of a brufh, it gives it a tranfparent varnifh like that gum, when dry. Neumann found that ten drachms of the white was reduced on drying to 2½ drachms; this change and lofs of weight is attributed to it's being deprived of it's water, which Cartheufer affirms compofes nine parts of it. When dried it is ftill foluble in cold water, and forms the fame vifcous fluid as before. By diftillation in a water-bath nothing is obtained but its water, and in proportion as it lofes this, it becomes harder and of a reddifh yellowifh colour, and refembles horn. If it has been previoufly coagulated it recovers it's tranfparency. Expofed on the open fire in a retort, to a ftrong heat, there comes over a ftinking empyreumatic oil with a great quantity of volatile alkali, and a coal remains as in other animal fubftances.

By fublimation Deyeux obtained a little fulphur from it. Acids coagulate it. Scheele has, however, obferved that very diluted acids diffolve it at the boiling point, and it is again precipitated by them in their concentrated ftate.

It is diffolved by cauftic alkalis and lime water, and precipitated from them again by acids; as this takes place an hepatic fmell arifes, and the vapours blacken filver and faccharum faturni. Cheefe having the fame properties, Scheele looked upon this matter to be cheefe in it's pure ftate. With lime it forms a very hard cement.

Metallic oxyds, according to Fourcroy, as thofe of

mercury (which do not form a very ſtrong union with oxygen) thicken it on being agitated with it, whilſt the oxyd becomes horn; in twenty-four hours the white was found ſolid, and the oxyd almoſt black.

On digeſtion with iron it is ſaid to diſſolve a ſmall portion of it.

Alcohol coagulates it, but ſooneſt when warm.

Cauſe of coagulation of the white.

With reſpect to the cauſe of the coagulation of the white of the egg, there has been ſeveral opinions. Scheele thought it aroſe from caloric or the matter of heat. Waſſerberg that it aroſe from being deprived of it's water, as is the caſe when it is heated with alcohol, at the ſame time he thought a ſpecific aſtringent power was likewiſe neceſſary. Fourcroy is of opinion that it ariſes from the combination of oxygen which is favoured by the heat produced. He divided the white of an egg into two equal parts, to the one he added a ſolution of carbonate of potaſh, to the other cauſtic potaſh, and he found that ſulphuric acid joined to the firſt produced no coagulation, but formed a thick coagulum on being added to the other; hence he affirms that the ſulphuric acid when mixed with the liquid albumen diſengages a great deal of caloric from it, which by favouring the intimate combination of the oxygen, produces the coagulation. This effect is ſtill increaſed by the cauſtic potaſh, which unfolds much more caloric than the white itſelf does, and beſides by abſorbing the ſulphuric acid and preventing it's union with the albumen, the potaſh proves that it is the impreſſion only of the caloric that gives riſe to the concretion: when, on the contrary, the white is mixed with the carbonate of potaſh in ſolution, the ſulphuric acid joined in the mixture, attacking the ſalt, diſengages the carbonic acid, which takes away the caloric and is volatilized to the ſtate of gas; the white therefore ought not to undergo any alteration, and in fact it remains

without being coagulated. From thefe and other facts, as that of it's being coagulated by oxyds, Fourcroy feems to fuppofe oxygen to be the grand principle of coagulation in the white. Againft this chemift, however, Corradori brings other experiments. He covered the white of a very frefh egg with olive oil, and expofed it to a heat of boiling water, and found the coagulation took place as if in the open air, although no air had the leaft accefs to it, or any elaftic air raifed the oil in order to efcape, fo that no decompofition of the water took place. He is alfo of opinion, that oxygen gas is not even abforbed by the white. He put fome white into a branch of a crooked tube, and plunged them into boiling water. The white foon coagulated, and the water in the open branch being always at the fame level, proved there was no condenfation of air, and the confolidated white had juft the fame volume as when in a liquid ftate. He remarks, that the coagulation always begins in that part which is the moft diftant from the air, or at the bottom of the veffel. His opinion is, that it arifes from a change produced by the folvent power of the caloric, in the difpofition of the integrant parts of the white to obey the force of cohefion.

Infpiffated white. Hatchett has made fome experiments on *infpiffated albumen.* He informs us, that as the albumen of the blood is mixed with gelatin and fibrin, and as it is with fome difficulty that the albumen can be feparated exactly from thefe fubftances, he preferred that of eggs, as being pure and unmixed, and in order that it might be brought into a ftate in fome meafure fimilar to fome fubftances which he had examined (for which *vide* Bone) he dried it after coagulation, in a veffel which was heated to 212 of Fahrenheit, until it became perfectly hard, brittle, yellow, and femitranfparent like horn.

1. After digeftion of a few hours, the tranfparent

horny pieces of albumen were foftened, and became white and opake, exactly like albumen recently coagulated. At the end of eight days, the water exactly refembled that afforded by quill, nail, and tortoife-fhell; for tanning principle had no effect, although nitro-muriat of tin produced a faint white cloud. The reverfe of this takes place in recent liquid albumen, for if the infufion of oak bark be added to it in that ftate, it immediately forms a precipitate, and nitro-muriat of tin does not produce any effect till fome hours have elapfed.

2. By diftillation, the coagulated dry femitranfparent albumen afforded fimilar refults to thofe mentioned (in the art. *bone*) as obtained from tortoife-fhell, &c.

3. A fpongy coal of difficult incineration remained. That which was foluble in water, and which was by far the moft confiderable, confifted principally of carbonat, mixed with a fmall quantity of phofphat of foda, the reft, as far as fo fmall a quantity could be afcertained, proved to be phofphat of lime.

4. When fteeped in dilute nitric acid, in about four weeks the acid began to be tinged yellow, which gradually became deeper in three months, however the albumen, although lefs tranfparent, was but little diminifhed. The yellow acid folution, when faturated with ammonia, changed to a deep orange colour, and remained tranfparent.

5. The albumen, thus fteeped, was immediately immerfed in ammonia, which changed it to a deep orange, inclining to a blood red, and by degrees entirely diffolved it; the folution was of a deep yellowifh brown.

6. If the albumen, inftead of being immerfed in ammonia, was wafhed, and then boiled in diftilled water, it was diffolved and formed a pale yellow liquor, which by evaporation formed a gelatinous mafs; this being diffolved again in boiling water was (like gelatin) pre-

cipitated by the tanning principle, and more ſlowly by nitro-muriat of tin.

7. By concentrated nitric acid, or by the dilute when heated, albumen was ſpeedily diſſolved with much effervefcence, and a copious diſcharge of nitrous gas.

8. This ſolution was like that of tortoiſe-ſhell and the other ſubſtances (art. *bone*).

9. When evaporated it afforded ſimilar reſults.

10. Albumen, like tortoiſe-ſhell, quill, and nail, was diſſolved by boiling lixivium of cauſtic potaſh, and formed animal ſoap.

11. In like manner alſo a conſiderable portion of ammonia was diſcharged, and if the alkali was in exceſs, ſome coal was depoſited.

12. The animal ſoap obtained from albumen, when diſſolved in water, yielded a precipitate by the addition of acetous or muriatic acid; and the precipitate was rediſſolved when the acid was added to exceſs.

13. This precipitate, when collected on a filter, appeared more ſaponaceous and leſs viſcid than that obtained from the ſubſtances art. *bone*; for this precipitate when obtained from hair, wool, and muſcular fibre, appeared in ſome caſes more and in others leſs viſcid, although ſimilar in every other property. When gently heated, ſome oil flowed from it; after which, a browniſh viſcid ſubſtance remained, ſimilar in it's properties to that obtained from the animal ſoap made by tortoiſe-ſhell, &c.

14. He found that inſpiſſated albumen, long boiled with diſtilled water, was apparently diminiſhed; but the water (like that in which tortoiſe-ſhell, quill, or nail has been boiled) had acquired the property of becoming white and turbid, when nitro-muriat of tin was added, although it was not changed by the tanning principle. Likewiſe the water in which albumen, or

tortoise-shell, or nail, had been boiled, became, in some measure, putrid, in a few days, and emitted an offensive smell. He, however, does not look upon this as a proof that any gelatin had been separated from these bodies by means of boiling water, but rather that inspissated albumen, tortoise-shell, &c. are substances really soluble, although in so slight a degree as to approach insolubility; and that, thus, the prevalent opinion has arisen concerning the insolubility of coagulated albumen in boiling water. It does not putrefy in it's inspissated semitransparent state.

Albumen, when merely coagulated, does not easily putrify, for Hatchett kept it, when it was soft, white, and coagulated, in water for a month, without it's becoming putrid; but that which has not been coagulated, but diluted with water, soon putrefies.

Berthollet, by means of the nitrous acid, extracted from the white a fat matter, and some saccharine acid.

Yolk.—This is a more or less yellow fluid, which in it's fresh state possesses the central part of the white, and is of a globular form. It consists of two parts, the one is an albuminous matter resembling the white; hence it becomes coagulated and hard by exposure to heat, acids, or alcohol, but less so than the white. The other part is a mild fat oil, which appears to exist in the yolk, in the same state as the oil in the seeds of some plants, and it is this oil that forms a very striking analogy between the eggs of animals and the seeds of vegetables. On this account the yolk is not entirely soluble in water, like the white, but forms with it a milk white fluid, which is called an emulsion, resembling that produced from vegetable seeds, and for the same reason it dissolves oily and resinous bodies, and makes them miscible with water. It Yolk.

likewiſe contains a conſiderable quantity of water, which is ſeparated on diſtillation.

It's oil. To obtain this oil, there are two ways: Firſt, by expreſſion. The yolk muſt firſt be deprived of it's water, by boiling; it is then to be put into a proper veſſel, upon a moderate fire, and kept ſtirring until it is obſerved to become ſomewhat ſofter, from the exuding of the oil; this is then to be preſſed out from the yolk, by putting it, in a little linen bag, between two warm plates; by theſe means Crantz found that fifty eggs afforded five ounces of oil. Secondly, ſince the heat neceſſary for roaſting produces a change, and a ſmell, Chandelier has found out a method of procuring the oil in a more perfect ſtate, and in larger proportion, without the aid of fire. Having well beaten the yolks, he put from two to three drachms of rectified alcohol to each, and diluted the mixture with ten times the quantity of water, in which he ſometimes diſſolved a very ſmall quantity of alum; he then let it repoſe twenty-four hours. By this method, from eight yolks he obtained six drachms of oil of eggs. This oil is of a yellowiſh colour, of a ſomewhat thickiſh viſcous conſiſtence, mild and inſipid; when, however, it is procured by means of heat, it's taſte and ſmell are ſlightly empyreumatic. It ſoon becomes fixed in the cold, and, according to Hildebrandt, it readily turns rancid. What remains of the yolk is albumen, from which, the laſt chemiſt has obſerved, a little gelatin may be extracted by water. The yolk, when boiled with cauſtic lixivium of potaſh, forms, according to Hatchett, a pale olive coloured concrete animal ſoap, which when diſſolved in water, and ſaturated with muriatic acid, is precipitated in the ſtate of mere fat. By incineration, the yolk affords a ſmall portion of the phoſphats of ſoda and of lime.

The yolk, from it's oily and albuminous nature, is ufed to unite oils, and oily fubftances, with aqueous fluids, forming *emulfions,* as they are called in medicine; which likewife forms a ftriking analogy between eggs and the feeds of moft vegetables.

Eggs are commonly preferved by packing them up very clofe in bran, fand, fawduft, and other fubftances that do not admit the free access of air; the yolk, however, in thefe cafes, fuffers a change, by becoming harder. Neumann kept an egg perfectly fweet from May to November, in falt water; and Reaumur found, that eggs may be kept perfectly fweet for years, by rubbing them *as foon as laid, with oil,* or other unctuous fubftances. Prefervation of eggs.

Wafferberg, examen chemicum ovi, in the collect. Oper. Med. Fafc. 1. p. 184. Scheele in Crell's neueft. Entd. T. viij. S. 150. Chandelier in Vandermonde's Journal de Médecine, T. 16, No. 5, p. 45. Fourcroy, in the Encyclop. Meth. art. albumen. Expériences et Obferv. touchant la Caufe de la Coagulation de l'Albumine, per le Doct. Carradori. Anfangfgrunde der Chemie von Hildebrandt, T. 3, 1794. Chemical Experiments on Zoophytes, by C. Hatchett, Efq. F. R. S. Phil. Tranf. 1800.

Blood.—Life, it is well known, depends upon a fluid which circulates through certain kinds of veffels in all animals, and which the ancients very properly expreffed by the name of the vital fluid. This has been, at all times, the fubject of inveftigation; and although, from the important part it acts in the general economy, by carrying life and heat even to the utmoft extremities of the organized machine, there is no fluid which requires to be fo thoroughly underftood, or demands a more ferious inquiry; the nature of the blood, and the laws that govern it's interior movements, in performing the offices it is defigned for, have, at prefent, been but Blood.

faintly developed; and the influence it has over the animal machine, during the various periods of exiftence, may be even looked upon as entirely unknown.

Two fpecies. Phyfiologifts, from the difference of colour of the blood in various animals, have diftinguifhed it into two kinds.

1. Red blood, which circulates in the arteries, and veins, and other parts, of the mammalia clafs, birds, amphibious quadrupeds, reptiles, and fifh.

2. White blood, which is found in the greater part of worms and infects, and has not yet been fubmitted to chemical analyfis.

From this difference of colour in the blood, thofe animals whofe veffels contain the red have been denominated fanguineous; and thofe containing the white, milky, or colourlefs fluid, exfanguineous animals.

The name of blood has likewife been ufed in a ftill more extenfive point of view, and has been beftowed upon that fluid which circulates in the veffels of plants.

First fpecies, or red blood. The firft mentioned fpecies alone has yet been analyfed. It is the moft important fluid in the body, and as to it's component parts, whatever be the diverfity of the animal, whether it be an inhabitant of the earth, or of the water, or of the air, nature feems to have followed the fame plan; it therefore affords no characteriftic mark whether it be taken from the human body, a quadruped, a fifh, or a bird; it always contains the fame component parts. It is fubject, however, to conftant variety; it differs greatly, according to the regions through which it paffes; it is not the fame in the arteries and in the veins, in the ftomach and in the region of the liver, in the mufcles and in the glands. It differs, according to the age, the fex, the temperament, and the ftate of health and difeafe. It is this variable ftate of the blood, changing in the proportions and modifications of it's

conſtituent parts, every moment, even in the ſame ſubject, that is the great obſtacle towards arriving at a perfect knowledge of it's nature and effects, and determining, by modern diſcoveries and chemical analyſis, the alterations it undergoes from the action of diſeaſe.

Blood, as it flows from the veſſels of a healthy animal, appears to be a red homogenous fluid; but, examined by the microſcope, ſmall flat balls are diſcovered, ſwimming in a thin, ſomewhat yellowiſh, liquid; and this is more particularly to be obſerved as it circulates in the veins of a living animal. It's properties.

It differs, however, in colour, according to the part from which it comes; thus, in the arteries it inclines to a bright vermilion colour, whilſt, in the veins, it is of a deep purple. Even in the extremities of the ſyſtem, the blood of an artery is red, and that of a vein dark coloured; ſo that ſurgeons are able to diſtinguiſh arterial from venous hæmorrhages. The blood coughed up from the lungs is florid, whilſt that of the womb, of ſinuſes, of varices, and of all ſtagnant veins, is black and offenſive. The face is livid, in apoplexies, ſtrangulations, drowning, in fits of paſſion, or coughing, or in any accident that interrupts the circulation through the lungs. The face of a child is completely black during the paroxyſm of the hooping cough; tumours are dark coloured, from dilated veins that return their blood too ſlowly; and the mulberry, and other marks, which are born with us, are, according to Bell, ſmall aneuriſms full of ill oxygenated blood. The menſtrual blood, that of ecchymoſis, of aneuriſmal ſacks, are all black; and the blood of varices is ſo very dark coloured, as to make the ancients ſuppoſe they were filled with *atra bilis*, or black bile. With reſpect to it's quantity, in the human ſubject, Planck aſſerts that an adult contains about

twenty-eight pounds of blood; four parts of which are allotted to the veins, and the remaining fifth to the arteries.

Blood is not ſo fluid as water, but has an unctuous or ſaponaceous feel, a ſweetiſh, ſaline ſavour, and it's aroma is ſomewhat urinous, fatuous, and peculiarly animal; which aroma is ſoluble in air, water, and ſpirituous liquors.

It's ſpecific gravity is greater than diſtilled water, being as 1053, or 1126 to 1000.

It's heat is different in the different orders of animals; human blood, and that of quadrupeds and birds, is about 96 of Fahrenheit, or 32 of Reaumur; whilſt, in oviparous quadrupeds, ſerpents, and fiſh, it is at the temperature of the medium they inhabit. The arterial blood is likewiſe warmer than the venous.

It unites with cold water, but boiling water coagulates it. Acids, when very much diluted, have no effect upon freſh blood, but, when concentrated, both the mineral acids and vinegar coagulate it, and change it's red colour to a dark brown.

According to Weber, the fixed and volatile alkalies change it's colour to a beautiful carmine red, without any coagulation; they even render it more fluid, particularly the latter. The fixed alkalies, when cauſtic, diſſolve it.

Lime water renders it more fluid, and increaſes it's colour.

Neutral ſalts, ſuch as nitre, common ſalt, &c. make it likewiſe more fluid, heighten it's colour and retard it's coagulation, whilſt alum and ſal ammoniac coagulate it.

Vitriols of iron and copper, particularly the latter, and ſpirit of wine when in a concentrated ſtate, likewiſe coagulate it.

If blood, recently taken from a vein, and either

purple or black, be expofed to oxygen gas, it changes to a vermilion colour, which however gradually difappears and becomes again purple, and laftly black, and no new impregnation can render it red again. On the contrary, if arterial blood, which is of a bright vermilion, be expofed to air in which there is little or no oxygen, *i. e.* to unrefpirable gas, it's colour is gradually changed to a purple. *Vide* Refpiration. Vaffali of Turin found that blood as it comes from an artery or vein is in a ftate of pofitive electricity, whilft excretions, as urine, &c. are in a negative ftate.

The blood, as foon as it is efcaped from the veffels, undergoes certain changes; if in a ftate of repofe, it firft coagulates into a red gelatinous mafs; but it foon begins to feparate into two parts. One of thefe, which is red and folid, is termed the *coagulum* or *clot*: the other is a yellowifh fluid, called *ferum* or *lymph*, in which the coagulum fwims. Spontaneous feparation in atmofpheric air.

If blood as it comes from the vein be put into a veffel void of air, or filled with an unrefpirable gas, it likewife coagulates, but not fo fpeedily, nor to that extent as in atmofpheric air, and the colour is rather black than red. On the contrary, if recent blood be put into a veffel containing oxygen gas, the coagulation proceeds rapidly, and the colour is as red or more fo than if it had been in atmofpheric air. According to Beddoes, the refpiring oxygen gas haftens it's coagulation. It likewife coagulates more quickly when allowed to flow flowly from a vein, and in fmall quantities; and more flowly when extravafated in the cellular membrane, than when expofed; in the laft cafe this congulation firft takes place on the expofed furface, and on the edges of the difh. In vacuo or unrefpirable gas. In oxygen gas.

During the coagulation of blood, according to Fourcroy, a quantity of caloric is difengaged fo as to raife it's temperature 5°, Difengagement of heat.

The coagulation prevented by agitation.

If blood be ſtrongly agitated by any mechanical means as it is received from the veſſels, this ſpontaneous change is prevented, nor can it be coagulated afterwards, according to Weber, either by acids, or alcohol, whilſt the alkalis heighten it's colour, and give it more or leſs tranſparency; it even becomes perfectly pellucid and fluid on the addition of the aqueous ſolution of ammonia, and it's colour is changed to that of the moſt beautiful cochineal. Agitated blood is likewiſe leſs inclined to the putrid fermentation.

It's putrefaction.

Blood readily putrefies, according to Weber, when expoſed to a temperature of 50° of Fahrenheit; it begins to have a diſagreeable ſmell on the ſecond day, which increaſes ſo rapidly as to be nearly inſupportable on the fourth; the coagulum then begins to change the ſerum to a darkiſh red colour, and it finally becomes ſo diſſolved as only to leave a few threads and lumps, and in this ſtate it has a ſtrong ſmell of volatile alkali.

Expoſure to heat.

Blood, when expoſed to a gentle heat, dries into a black maſs, termed the extract of blood. On diſtillation, it affords an inſipid phlegm, which quickly putrefies, an empyreumatic oil, and a neutral ammoniacal ſalt conſiſting of an acid, which is moſt probably the zoonic, ſuperſaturated with ammonia. During this operation, the blood becomes very intumeſcent, evolves much hydrogen, carbonic acid gas, pruſſic acid, and by an exceſſive heat, a thick irritating ſmoke which is phoſphorus in a ſtate of combuſtion; and there remains a heavy ſpongy coal of difficult incineration, which when reduced to aſhes, affords carbonat and muriat of ſoda, phoſphat of lime, and oxyd of iron.

1. White ſerum.

Serum. This is a yellowiſh tranſparent liquor of a greeniſh tinge.

It's properties.

It is of an adheſive conſiſtence, has ſcarcely any aroma, but is ſomewhat ſaline to the taſte; according to Plenck,

it forms fcarcely half of the blood. On agitation it foams exceedingly.

The fpecific gravity, according to Jurine, is to water as 28 to 1.

It is foluble in water to 55° of Reaumur, or 160° of Fahrenheit, when it coagulates. This is however prevented by dilution with water. In a coagulated ftate it is of a white colour, refembling boiled white of egg in odour and confiftence, and during it's coagulation a flightly turbid liquor feparates, which is *gelatin*.

It is to be feparated from it's folution in water by alcohol.

It changes the fyrup of violets to a green colour.

Acids coagulate it when fufficiently ftrong, and the liquor remaining after filtration contains a neutral falt arifing from the union of the acid and foda, but in fmall quantity. It is alfo coagulated by alcohol.

Alkalis render it more fluid.

Serum does not decompofe calcareous or aluminous falts, but it acts with fufficient energy in the decompofition of metallic falts.

It blackens the metallic fplendour of filver.

During it's coagulation heat is difengaged, and the caufe of it's taking this concrete form is owing, according to Fourcroy, to the abforption of oxygen.

Coagulated ferum is infoluble in water.

It is foluble in concentrated mineral acids, which folutions are decompofed by water.

Cauftic alkalis likewife diffolve this concrete ferum, and the folutions are decompofed by acids.

By a moderate heat it dries into a corneous mafs.

Hence it appears, that coagulated ferum is very fimilar to the cheefy part of milk.

If coagulated ferum be treated with diluted nitric acid, by the aid of heat, nitrous and azot gafes will be obtained, Affords oxalic and malic acids.

while the oxalic as well as a ſmall portion of malic acid will be found in the reſiduum.

Diſtillation. If fluid ſerum be diſtilled on the water bath, it affords an inſipid phlegm, and a coagulum remains. On increaſing the heat, it intumeſces greatly, and produces carbonic acid gas, liquid and fixed ammonia, and a thick empyreumatic oil; a large reſidual coal remains, which is with difficulty reduced to aſhes, containing common ſalt, carbonat of ſoda, and phoſphat of lime.

It's component parts. It appears from the preceding experiments, that the ſerum of the blood is the albuminous part of it, and that it conſiſts of albumen, a little gelatin, ſulphur, muriat and carbonat of ſoda, and phoſphat of lime. It is ſaid, that the gelatin is the acidifiable baſis which may be changed into malic and oxalic acids, but the albumen is the body that by dry diſtillation affords oil, and is chiefly diſtinguiſhed on account of it's property of coagulation by heat, on which account the blood of animals is uſed in clarification.

2d. *Coagulum or clot.* This has likewiſe been called the *Craſſamentum.* It is compoſed of two parts, which appear to have been partially ſeparated by a ſpontaneous action, but which may be entirely ſo by artificial means.

2. Red ſerum. If the coagulum be well waſhed in cold water, the red part is diſſolved by it, to which it communicates it's colour, and there remains a white fibrous ſubſtance which is the *fibrin* of the blood. The water thus tinged by the coagulum contains in reality all the colouring matter of the blood, and ſince when chemically examined, it proves to be the ſame as the white ſerum, except it's containing a great deal of iron, it may be called, in order to diſtinguiſh it from the other, the *red ſerum.* This iron is to be ſeparated from it ſeveral ways, by incineration, or by reagents.

Difference between it and white ſerum.

3. Fibrin. The fibrous part of the blood, or fibrin, having been

well washed off the red serum or colouring matter, is perfectly tasteless, and of a white colour. It's properties.

It is insoluble in water.

Exposed to a moderate heat, whether by boiling or by other means, it becomes hard; and if this exposure be sudden, it shrinks up like parchment.

Caustic fixed alkalis only dissolve it by the acid of ebullition, and caustic ammonia has no effect upon it.

Acids dissolve it, and nitrous and azot gases are extricated during the solution, and it is precipitated from them by water and alkalis, in a changed state.

On distillation in the dry way, it affords much aerated ammonia, and a very thick fetid and ponderous empyreumatic oil. The residuum, which is not very bulky, is compact, heavy, and easy of incineration. The ashes are very white, and contain neither soda, neutral salts, nor iron, but they afford pure lime, and phosphat of lime.

Exposed to a moist atmosphere, it very readily putrefies, swells, and affords a good deal of ammonia.

In inflammatory diseases, it is partly separated in the blood, and covers the coagulum in the form of a yellowish tough cuticle, commonly called the buffy coat of the blood.

Proximate parts of blood.

Hence it appears that the blood is capable of being separated into three parts: 1. The white serum. 2. The red serum; and 3. the fibrin. Of these the white serum exists in the largest proportion, then the fibrin, whilst the red serum forms the smallest portion; but they vary in their proportions, according to age, &c.

Remote parts.

If these three proximate parts be reduced to the utmost analysis of which chemistry is capable, the remote component parts consist of oxygen, azot, hydrogen, carbon, sulphur, phosphoric acid, soda, lime, and iron, to which may be added the peculiar aroma of the blood. It is to these few ultimate and indivisible parts that the

analytical ſcience has been able to reduce this rich and wholly animalized fluid, which appears to be the primitive principle of all animal ſubſtances, and the common origin of all the animal ſolids and fluids; and ſince it conveys, during it's circulation through the veſſels of the ſyſtem, the principle of life to every part, which on being deprived of it dies, and becomes ſubject to the laws of ſpontaneous decompoſition or putrefaction, the ancients were right in their aſſertions, that the blood was the vital fluid.

Having given a general view of the nature of the blood, of it's ſpontaneous ſeparation into it's proximate component parts, and the effects that the chemical agents have upon them, it will be neceſſary to trace the outlines of it's hiſtory, and the chief experiments of the principal authors who have enriched the ſubject by their diſcoveries.

The ancients were of opinion, that the vital fluid or blood, which of all the animal fluids is the moſt univerſally diſtributed throughout the body, was a compoſition of the other animal matters; and Hippocrates, perhaps, from it's reſemblance in colour to that of the muſcles, called it running fleſh; but they had not ſupported their

Ancient analyſis.

conjecture by any chemical analyſis, and it would have remained as a mere fanciful opinion, had not modern experiments aſcertained, that the ancients were not very far from having aſſerted the truth. Before the time of Rouelle, very few chemical experiments had been made upon this fluid, and thoſe by no means ſatisfactory. With reſpect to the changes it underwent on expoſure to

By diſtillation obtained phlegm.

heat, they procured by diſtillation a water which they called *phlegm*. Vieuſſens found this phlegm to have very little odour or ſavour, and Homberg having procured fourteen parts from ſixteen of blood, thought that his experiments proved, on being compared with others, that

this proportion of water was much lefs in plethora, gout, and fcurvy, and increafed in confumption, and a phlegmatic temperament. On continuing the heat, Boyle obtained an oily and reddifh fluid, of a bitter favour, and manifeftly urinous nature, to which he gave the name of *fpiritus fanguinis*, which confifts according to him of volatile alkali diffolved in the above phlegm. He got rather more than fix parts from twenty-four of blood. Grew obtained, after this fpirit, *fal volatilis* in a folid ftate, of a white colour, a ftrong and penetrating fmell, and effervefcing ftrongly with acid liquors. According to Needham twenty ounces of the extract of blood contain about two drachms of it, whilft Verduc got one part from fifty-two of the extract. With this falt, but fomewhat later, Boyle obtained a yellow oil, called the *oil of blood*, and by a ftrong heat a pitchy oil that effervefced with acids. This oil was fuppofed to arife from the fat part of the blood. From 179 parts, Vieuffens obtained four parts of this oil. The remainder, after this expofure to heat, was a fplendid, light, fpongy, black dreg, of a faline and bitter tafte, of an inflammable nature, which Helmont and Boerhaave called the *coal of the blood*, others the caput mortuum; this they found to contain earth, marine falt, fixed falt, oil, and a very heavy oil which was evident from the deflagration, and reddifh afhes compofed of falt and iron remained behind. Hales likewife found an *aerial fluid* in blood, forming the 33d part of it.

Spiritus fanguinis.

Sal volatilis.

Oil of blood.

Coal.

Aerial fluid.

With refpect to the action of reagents on blood, it was afferted by Boerhaave and Schwenke, that vegetable acids made it thinner; and by Eller and Courten, that foffile acids made it thicker or coagulated it. According to Boyle, alkalis rendered it more fluid, hence the neceffity of taking acids to counteract it's fluidity; Quefnai, on the contrary, thought they thickened it. As to the neutral falts, Stahl afferted that nitre coagulated blood.

Action of reagents.

Neumann in his examination of this fluid obtained ſimilar reſults by diſtillation to thoſe of his predeceſſors, viz. an urinous ſpirit, a concrete ſalt and an oil. Lewis, who examined it more minutely after evaporation and inſpiſſation, found the exſiccated blood to be ſoluble neither in acid nor in alkaline liquors, that it communicated ſome colour to water and ſpirit of wine, and that it was more particularly acted upon by dulcified ſpirit of nitre. In his examination of recent blood, he found, that it was coagulated by the mineral acids, and by moſt of their combinations with earthy and metallic bodies; whilſt vegetable acids and ſolutions of neutral ſalts produced no coagulation: that it's fluidity was increaſed by alkalis both fixed and volatile, by which it was preſerved from coagulation: that the ſerum is not ſo much diſpoſed to putrefy as the craſſamentum: that it is ſomewhat more difficultly congealed by cold than pure water: that it coagulates by a heat a little greater than that of the human body: and that both this coagulum and the inſpiſſated ſerum are very inflammable in the fire, and inſoluble in water or ſpirit of wine, in acids or alkaline liquors.

Inſtead of making, however, any progreſs in the analyſis of this fluid, the attention of philoſophers was taken up in examining it's texture by means of the microſcope, and a variety of opinions was the conſequence, which will be found in the article *red particles*.

Rouelle publiſhed his work in 1773, and ſince this work appeared to the preſent time there is perhaps no fluid in the animal body, that has undergone ſuch a variety of inveſtigation, and been ſubmitted to more experiments than the blood.

As the microſcope was found to be of little uſe, chemical agents were reſorted to. After having treated this fluid by diſtillation, maceration, fermentation, &c. che-

miſts had recourſe to other methods. At firſt, the ſaline taſte of blood made them preſume that it contained ſome kind of ſalt, but no one could account for it's coming there. The firſt idea was, that it's ſalt or ſalts were introduced by means of the aliments perfectly formed, but from want of knowledge, no one ſuſpected that nature was able to produce them in the animal as well as ſhe had done in the vegetable kingdom: in the determination therefore of theſe ſalts the opinion of chemiſts was for a long time divided. Some ſuppoſed that the ſalt was the muriat of ſoda; others pretended it was an alkali; and ſome even doubted of the preſence of theſe ſalts, ſince thoſe who admitted them, had obtained them only from the reſiduum of combuſtion, during the laſt effort of the fire to which the blood had been expoſed, whence they concluded that they were the products of combuſtion, and not component parts of this fluid.

There were ſome chemiſts who went even farther, and ſuppoſed that an acid as well as an alkali exiſted in the blood. Amongſt theſe particularly was Homberg, who aſſerted that this acid does not ariſe till towards the end of the diſtillation.

However fanciful the ſuppoſition was of it's containing an acid, it appeared however, and more particularly from the inveſtigation of Haller and de Haen, that different ſaline matters exiſted in this fluid. It was particularly to be obſerved from that of de Haen, that the water in which the coagulum had been waſhed gave evident traces of an alkali, and that exſiccated blood effervesced with acids, but it ſeems that the two chemiſts doubted of it's exiſtence. "Not one experiment," ſays one of theſe celebrated men, "is there to prove that "there exiſts pure and diſengaged ſalt in the blood, not "one phenomenon characteriſtic of acid or alkali." It therefore remained to determine after the ſlight veſtiges

of an alkali, of what ſpecies it was, in what quantity it was preſent, and whether it exiſted in a free or united ſtate: this was effected by Thouvenel, but more particularly and ſatisfactorily by Rouelle.

Rouelle. Having made the obſervation, that not only the aqueous part of the blood or ſerum, but the water of all dropſical parts poſſeſſes the ſame properties as the white of egg, of being coagulated by moſt acids as well as by a boiling heat; likewiſe of uniting with water and changing the blue colour of violets to a *green* in the ſame manner as if a little alkali had been put into the water; Rouelle concluded, that as the water ſeparated from blood by diſtillation had no effect on the ſyrup of violets, except after having been kept ſome time, the property of changing the vegetable ſyrup did not proceed from any alkaline nature of the ſerum, or from it's volatile alkali, as ſome writers had ſuppoſed, but from a real diſengaged fixed alkali. He ſupported this aſſertion by the properties of the more or leſs coloured maſs remaining after diſtillation of blood. This which is pulveriſable, and reſembles externally a glue, but differs from it by being difficultly ſoluble in water, is found in time to have it's ſurface covered over with a cryſtallized ſalt, whilſt the maſs has regained it's tenacity by attracting moiſture from the air. But he proved by experiment that the blood contained this uncombined alkali; for on taking a quantity of ſerum either of the blood or from a dropſy, adding to it twice as much diſtilled water, and then mixing a little vitriolic acid with it and diſtilling it to dryneſs, he found, that on adding ſome boiling water to the remainder, and ſaturating the acid liquor, or rather the ſuperabundant vitriolic acid with chalk, a real *Glauber's ſalt* was obtained. Inſtead of the vitriolic acid he uſed diſtilled vinegar, and the conſequence was acetated ſoda. Hence the ſerum contained mineral alkali. In 1776 Rouelle publiſhed ſome other ex-

periments on the ſaline matters which the blood contain. They were made on that taken from different animals, ſuch as the human, the ox, the horſe, the calf, the ſheep, the pig, the aſs, and the goat. In theſe, he proves, that the calcined aſhes contained in the blood of a healthy perſon afforded natron or mineral alkali, common ſalt, digeſtive ſalt in ſmall quantity, an animal or calcareous earth, iron and a coal. He found that theſe were in various quantities, 28 or 29 parts of alkali to 16 or 17 of the neutral ſalts, whilſt the animal earth formed the 10th part, and the quantity of coal was very inconſiderable. That on diſtillation and cryſtallization of the aſhes, the common ſalt was firſt obtained, then the digeſtive, and afterward the natron or baſis of common ſalt, and that the proportions of theſe were never the ſame in every ſort of blood. Such are the experiments of this celebrated chemiſt on the ſerum of the blood, by which he for ever fixed the opinion of it's containing ſalts, ſuch as ſoda and the muriats of potaſh and ſoda.

After Rouelle, the next chemiſt of any conſequence is Bucquet. He communicated his experiments to the Academy of Sciences, amongſt which are ſome intereſting obſervations upon the different alterations the blood undergoes in it's ſpontaneous decompoſition. According to this chemiſt, the coagulation of the *ſerum* or lymphatic part of the blood is not occaſioned by the loſs of it's aqueous part or by exſiccation, but is produced by the peculiar action of heat. He found that the water of diſtillation was at firſt taſteleſs, and did not affect ſyrup of violets; yet that it was not pure, but contained animal matter, ſince it became putrid in time, and changed the ſyrup to a green from the volatile alkali that was extricated. He found that on diſtilling the exſiccated ſerum it afforded a volatile alkaline ſpirit, fixed volatile alkaline ſalt in large quantity, and an empyreumatic oil, the Bucquet.

greater part of which funk beneath the fpirit. The remaining coal was light and fpungy, and nearly filled the belly of the retort, and afforded a great deal of common falt and fixed mineral alkali. It was difficult of incineration, and contained an uncommonly fmall quantity of iron when the ferum was free of any red part. He likewife found that the ferum mixed in all proportions with cold water. If poured into boiling water one part was coagulated, whilft the other formed a kind of union with the water; he does not however think it was a perfect folution, for it remained white and fomewhat milky, and could not be rendered clear by repeated filtration. If boiled, it fwelled, and a pellicle arofe on it's furface as is the cafe upon milk, and the addition of acids or alcohol coagulated thofe parts that prevent it's tranfparency.

It was ftrongly difpofed to putrefaction, for having expofed a little of it to the air it became putrid in fo fhort a fpace of time, as to prevent his being able to determine whether it had previoufly undergone the acetous fermentation.

From other experiments made upon it, it appears, diluted acids coagulated it, and by filtration a fluid was feparated, which was eafily diffolved by the concentrated nitrous acid after having been firft coagulated by it. This folution was accompanied with a ftrong effervefcence, and the diffolved part was precipitated by water.

Alkalis did not coagulate the aqueous lymphatic part of the blood, and even the cauftic volatile alkali eafily diffolved it when coagulated. This folution was decompofed again by any of the acids.

The neutral falts, whether with an alkaline or earthy bafis, had no action on this fluid part; but almoft all thofe with a metallic bafis caufed a confiderable precipitation.

With refpect to alcohol, it has been already obferved

that the ſecond part, even that which unites with water, is coagulated by it; but it is a curious circumſtance that the ſame coagulated part is capable of again being diſſolved, and in pretty conſiderable quantity, in water, which is not the caſe with that which has been coagulated by acids.

The analyſis of the ſerum being once known, it remained to examine the coagulum, the red colour of which had given riſe to much diſcuſſion, and ſince the inveſtigation of the red particles forms an æra in the hiſtory of microſcopical obſervation, it is neceſſary to give ſome account of their examination.

The diſcovery of the red particles in the blood was made towards the end of the laſt century. Lewenhoeck was the firſt who, having expoſed the leg of a frog to the lens of a microſcope, affirmed that the living blood conſiſts of a number of red globular particles ſwimming in a large quantity of a tranſparent liquor. Elated with this diſcovery, he enjoyed himſelf in the regions of fancy, and imagined that each of theſe globules was compoſed of ſix ſmaller ones packed together, that while the ſix continued to adhere, their colour was red, but being ſeparated, they became yellow and formed *ſerum.* His imagination carried him further, and he pretended that each of theſe ſerous globules conſiſted of ſix ſmaller ones, which when ſeparated formed a more ſubtile and penetrating liquor than the ſerum itſelf. This theory, wild as it may ſeem, gained many admirers; it was even acknowledged as founded on facts, ſerved to advance other theories, and gave riſe to elaborate calculations, which now only ſerve to amuſe the curious.

Red particles.

Lewenhoeck.

The great confidence which had been given to microſcopical inveſtigation invited other philoſophers to examine the blood, and about the middle of the preſent century Father della Torre, on examining the red particles, found them to be of an annular figure, with a perforation in the middle,

Father della Torre.

and the ring itſelf to be formed of ſeveral joints. The wonderful degree of magnifying power, however, which the lenſes he made uſe of were ſaid to poſſeſs, rendered the accuracy of his experiments doubtful, and ſome of them having been examined by the Royal Society, who failed in making ſo ſucceſsful an application of them, the credit of this philoſopher's diſcoveries reſted on his own evidence.

Hewſon. To Father della Torre ſucceeded Hewſon, who very carefully purſued a ſimilar rout. He found, contrary to Lewenhoeck, that the red particles of the blood, when examined by the microſcope, were flat in all animals, and conſequently improperly called *globules,* and that they were of very different ſizes in different animals. In man they are ſmall and flat as a ſhilling, with a dark ſpot in the centre. In order to examine them with more diſtinctneſs, he diluted the blood with freſh ſerum, which precaution having been omitted by his predeceſſors, they were only able to ſee them very indiſtinctly. As to the black ſpot, the particles of the human blood being very ſmall, he found it difficult to determine, whether it was a perforation, as ſome imagined, or not: but he diſcovered in the frog, where it is ſix times larger than in man, that it was a little ſolid body contained in the middle of a veſicle. Inſtead therefore of calling the particles of blood red *globules* he thought red *veſicles* would be more proper, each particle being a flat veſicle with a little ſolid ſphere in it's centre.

He found the blood of all animals contained veſicles of this ſort. In the human and that of quadrupeds there are millions of them, and they give it the red colour. In inſects they are white and leſs numerous in proportion. He found that their flat ſhape was alterable by mixing them with different fluids, and that it is by a determinate quantity of neutral ſalt contained in the ſerum, that this

fluid is adapted to preferve them in their natural flat fhape; for if mixed with water they become round and are perfectly diffolved, but on the addition of a little of any neutral falt to the water, they remain in it without any change of form, or without folution; hence Hewfon fufpected the fhape of thefe particles to be a circumftance of fome importance. He found that on diluting the blood of a frog or toad, with the ferum of the human blood, the particles which are large became flat, as is the cafe in the veffels of that animal, whilft a little water firft made them round, and then began to diffolve them; a neutral falt gave them their flat fhape, but if this was not added, the vefi-cle was gradually diffolved by the water, and the little fphere was left alone. He found that the particles in the blood of infects, whether aquatic or earthy, were fimilar in figure to that of other animals, but differed from them in colour. Such are the microfcopical obfervations of this celebrated phyfiologift.

A more laborious inveftigation of the figure and fize of thefe red particles has been made by Cavallo. He defends the falling credit of Father della Torre both with refpect to the inftruments he ufed and his experiments. He does not find that any lenfes or globules of very great magnifying power were ufed before the time of that philofopher, who conftructed them of wonderful minutenefs, and at the fame time clear and diftinct, and it is from the great difficulty in their conftruction, and in their ufe as magnifiers, that he attributes the caufes why fo few have repeated della Torre's experiments, and why moft of them have been unfuccefsful, which want of fuccefs has thrown fuch fufpicions on his experiments and obfervations. Cavallo after much trouble fucceeded at laft in conftructing a few microfcopical globules after his method, and having repeated his experiment on thefe globules with an apparatus made exprefsly for fuch delicate work, Cavallo.

he found the defcription that della Torre has given of the appearances to be very accurate, although his conjectures may have been fometimes crude or miftaken.

From the experiments of Cavallo it appears, that the mean fize of the red particles differs very little in perfons nearly of the fame age; that they differ fomewhat in the fame perfon; and that their figure is not very circular: but this deviation from the circle is not fuch as a flat circular furface would affume in it's different inclinations to the axis of vifion, for the flat circular furface (according to the rules of orthographic projection) muft appear either circular, or elliptical, or as a ftraight line, whereas this experimentalift never perceived thefe red particles to form ftraight lines, *i. e.* edgewife, and the elliptical figure they fometimes affume is by no means regular.

In an adult perfon he found the diameters of the red particles from 0,0003 to about 0,0004 parts of an inch, and feldom fmaller or larger. If therefore the fmalleft of them were fet in a row, 3334 will be equal to one inch, and if the larger, about 2500.

When thefe particles are magnified more than 40 or 50 times, and lefs than 80 (in diameter) they appear like colourlefs tranfparent fpots, enclofed within dark circles.

When magnified more than 80 and lefs than 160, a dark fpot appears in the centre of each, refembling a dot made on paper with ink. He found that if the reflector that illumines the particles, inftead of being placed before the object, be fet on one fide of the axis of vifion, fo that the light may be obliquely thrown on the object, one half of the dark circle of each particle difappears, which is that on the fide oppofite the reflector. At the fame time, the central fpot appears to change it's place. When the particles are magnified about 200 times, the central fpot appears converted into a circle enclofing a tranfparent fpace. The diameter of this inner circle equals half of

that of the external one, but the proportion of theſe diameters, or the ſize of the internal circle, may be brought to increaſe or decreaſe by the leaſt alteration of the diſtance between the object and the lens, and by the ſame means the ſpace within the inner circle may be rendered clearer or darker than that between the two circles. The poſition of the inner circle is changed by the direction of the light: for if the particle of blood be viewed through a microſcopical globule of glaſs directly facing the flame of a candle, without the intermedium of any lens or reflector, the inner circle will appear concentric with the outer one; but if the candle be moved a little to one ſide, that the light may fall obliquely on the particle of blood, the inner circle will be obſerved to move towards the oppoſite ſide, and to acquire an elliptical ſhape.

When the particles of blood are magnified above 400 times, an imperfect image of the candle, which is placed before the microſcope, may be ſeen within the inner circle of each particle. Through a glaſs globule of 0,018 of an inch in diameter he has ſeen the red particles magnified about 900 times, in which caſe the image of the flame of the candle could be ſeen within the inner circle of each particle very clearly, at leaſt ſo as to ſhow to which ſide the motion of the air in the room inclined it. Although the magnifying power was ſo great, yet the annulus or ſpace between the two circles did not appear to be divided, except ſome accidental fractures ſometimes ſeen in a few of the particles.

From theſe obſervations, this philoſopher thinks that the red particles of the blood are not perforated, but that they are globular, and compoſed of ſome uniform ſubſtance much leſs tranſparent than glaſs. They likewiſe ſhow that Hewſon's idea of their containing a central body, or nucleus moveable within the external ſhell, aroſe from the apparent change of place which the

various direction of the light produces on the central ſpot or inner circle of each particle.

On the ſuppoſition of theſe red particles being globular, he expected to find that globules of other tranſparent matter would exhibit the ſame appearances, and his expectations were in great meaſure verified. The ſhades of difference he obſerved between them were: Firſt, that the glaſs globule ſhowed a diſtinct, whilſt the red particle ſhowed an indiſtinct image of the candle: Secondly, that the inner circle of the globule is much ſmaller in comparifon with it's external boundary than the inner circle of the particle is, compared with it's external one: Thirdly, that the annulus is uniformly dark in the globule, whereas in the particle it is as clear or clearer than the internal ſurface.

On examining theſe particles in the living animal, if any thin and tranſparent part, ſuch as the tail of a ſmall fiſh, or the membrane between the toes of a frog, be viewed through a good microſcope, the circulation of the blood through them is only perceived by the motion of theſe red particles, which follow each other at a greater or leſs diſtance, although in general, each particle ſeems to touch, or nearly ſo, the following one. They are never ſeen to run into each other and incorporate, and though not very hard, they are poſſeſſed of a certain degree of conſiſtency and elaſticity, for in paſſing through the very ſmall veſſels, they are frequently ſeen to aſſume an elliptical ſhape, whilſt from the ſmalleſt veſſels they are abſolutely excluded.

By labour the red particles may be accumulated in a wonderful degree; thus, in hard-working people they abound, and by the exerciſe of particular parts the ſame takes place, as in the wings of thoſe birds accuſtomed to fly, and in the legs of thoſe accuſtomed to walk a great deal. They are numberleſs in health and in all ſtrong creatures,

whilſt in diſeaſed and weak animals they are in ſmall quantity.

Cavallo, on continuing his experiments on the red particles, found that they loſe their ſhape and are diſſolved in certain fluids, that this does not take place in the ſerum of the blood or in urine, except when left in theſe fluids for ſeveral days, or when theſe fluids are diluted with water. But water alone he found to be a powerful and almoſt inſtantaneous ſolvent for them, although it may be deprived of this property by the addition of common ſalt, or nitre, or of any other neutral ſalt, as well as by the admixture of a very ſmall proportion of the vitriolic acid. He found that the marine acid, when much diluted with water, had no ſolvent effect upon them, but it's action deprived them of their colour. Vinegar is likewiſe a powerful ſolvent, but not equal to water. He found that when once they were dried or diſſolved in water, they were not capable by any means of reſuming their former ſhape: and it appears that their formation even in the animal body is accompliſhed with great difficulty, at leaſt much leſs expeditiouſly than that of the other component parts of the blood; for in thoſe animals that have loſt much blood, although the ſanguiferous veſſels are ſpeedily filled with red blood, yet it continues thin and pale for a conſiderable time, and when examined by the microſcope, few red particles are to be found in it. This ingenious philoſopher does not attempt to offer any further conjectures reſpecting the nature and conſtruction of theſe particles.

The next circumſtance to be conſidered is their colour. It was ſuppoſed by the ancients that there was only one kind of blood; thus Eraſiſtratus taught that the veins contained the blood, whilſt the arteries only contained a ſpirit. Galen, however, ſpeaks of the blood on one Their colour.

ſide of the heart being more florid than on the other, which florid blood was the arterial. The celebrated Harvey, and the firſt believers of the circulation, were of opinion that there was no difference between the arterial and venous blood, either in colour, denſity, or in their elements. Some time after Harvey, when the ſubject of the redneſs of the blood came to be inveſtigated, it gave riſe to many diſputes. Some pretended, as the microſcopiſts, that it aroſe from the reunion of a certain quantity of globules, and the colour diſappeared on their being divided. Hoffmann thought he had found the cauſe in the union of the alkali with the ſpirituous matter, which he ſuppoſed to exiſt in the blood. Other chemiſts attributed it to different ſalts, and it was obſerved by Senac, in his work on the heart, that ſalts might augment it's red colour without increaſing it. After making various obſervations, he relates that the arterial blood is always of a more red and lively colour than the venous; that this colour is the more exalted as the action of the arteries is the more violent; that in young people it is more red and high coloured than in old: and theſe obſervations were ſufficient for ſome authors to find the cauſe of the redneſs in the action of the veſſels, in the multiplicity of the globules, and in the ſeparation of the lymph; but the numberleſs objections to which theſe theories were expoſed ſoon made it neceſſary to form more ſatisfactory explanations.

Several old authors had obſerved that blood, when agitated in the open air, immediately acquired a redder colour than before; and this act, which till now had not appeared to be very intereſting, immediately fixed the attention of phyſiologiſts, and there was reaſon to believe that it might lead to the cauſe. Hewſon, after many careful experiments, announced, although it had been done before him, that the combination of the air

with the blood was fufficient to colour this fluid. The only difficulty now was to indicate what body it was in the blood, that the air principally fixed upon in order to become the colouring principle, and this difficulty was foon taken away on recollecting that the blood contained iron. This difcovery is due to Badia, who is faid to be the firft that found iron in this fluid, and all opinions united and agreed to confider the combination of iron with the air as the caufe of the red colour. Iron.

Experiments of Menghini.

Menghini is the chemift who appears to have the beft followed the conftant and uniform track of nature, relative to the diftribution of this metal in blood, the prefence of which deprived of it's colouring part, is a fact equally important as the difcovery of a free alkali. Some chemifts fuppofed, and amongft thefe were Geoffroy, that this metal being found in the afhes of blood was the effect of the fire; others, as Lemery, pretended that it was already formed in the blood, and that the fire only expofed it by deftroying the bodies with which it was mixed; whilft others believed it to be the production of the veffels in which the combuftion of the blood had been made. Amidft thefe doubts and conjectures, Menghini continued to feparate the iron without the affiftance either of calcination, or any inftrument the influence of which might be fufpected: the method he made ufe of was to dry fome blood by a ftove heat, and he found that the powder obtained, when expofed to the loadftone, became very fenfible to the magnetic impreffion. He found that there was a more confiderable quantity in the human blood than in that of quadrupeds, that there was lefs in fifh, and ftill lefs in that of birds: and he concludes, that in the animal body the blood is the only true receptacle for it, and the experiments and obfervations which have been made, fince thofe of this learned

Italian chemiſt, have confirmed and developed the truths that are eſtabliſhed in his works.

Rouelle had likewiſe paid particular attention to the examination of the *coagulum* of the blood; but a premature death interrupted his labours, and deprived the ſcience of chemiſtry of one of it's moſt diſtinguiſhed votaries. This examination, indeed, required both phyſiological and chemical knowledge, and Bucquet, who appears to have united both with a great deal of induſtry and perſeverance, is the next author to whom we are to look for information.

Bucquet. This phyſician, whoſe experiments on ſerum have been already related, has likewiſe made the *coagulum* the ſubject of his reſearches.

The coagulum, according to this chemiſt, is compoſed of two parts, the *fibrous matter* and the *ſanguineous globules*. He conſiders the fibrous matter as having the greateſt tendency to become concrete of all the circulating fluids, and he thinks, that when once coagulated, it cannot be diſſolved by water. The ſmalleſt degree of warmth is ſufficient to harden it in a peculiar manner, and before it has even loſt it's moiſture. It then immediately becomes of a dirty gray colour, diminiſhes in volume, and becomes contracted like parchment. It gives on diſtillation nearly the ſame products as the ſerum, but the remaining coal is much thicker and more ſolid. If it be well waſhed before diſtillation, the coal contains neither common ſalt nor mineral alkali. It is much eaſier incinerated than the coal from the ſerum, and it's very white aſhes contain neither ſalt nor iron.

He found that this fibrous part was not to be diſſolved by boiling water; but became rather hardened and of a gray colour. It is likewiſe ſoluble neither in alcohol, oils, yolk of egg, alkalis, nor in the cauſtic volatile alkali, which ſo readily diſſolves the coagulum of the ſerous

part; but is eafily diffolved by all the acids, even by vinegar, and it may be again feparated from them either by water, or ftill better by alkalis. Thefe properties are very curious, and according to this chemift, refemble moft of the properties of the glutinous part of flower, and of the cafeous part of milk.

With refpect to the red part of the coagulum, or red globules, they may be eafily feparated from the fibrous part by fimple lotion, and the tranfparency of the coloured liquor announces a perfect folution of them. In this ftate he thinks it differs very little from the ferum, except in colour. It is like the ferum coagulated by heat, by acids, and by alcohol, and is foluble in volatile alkali, and affords the fame products by diftillation. It's coal is likewife equally light, contains common falt and mineral alkali, and is of difficult incineration. He has however obferved that the cinder or afhes have their brown red colour from the iron they contain; it refembles the colour of the faffron of Mars, and is in large quantity. In his idea, therefore, of the coloration of blood, he has adopted the fentiment of Menghini. He alfo believes that the want of colour, or the decoloration of this fluid in certain chronic difeafes, is owing to the abfence of this metal, and that the colour is again to be reftored by the ufe of martial preparations.

Although the ingenuity of chemifts, particularly of Sage. Bucquet, had made great progrefs in the examination of the blood, they had not found out under what form it was that the iron exifted in it, nor was there any more certainty to be collected from the idea of Sage, who conjectured that it was prefent in a ftate of combination with the phofphoric acid.

At the time Bucquet publifhed his experiments on this important fubject, a revolution was preparing in the fcience of chemiftry, which, by adding new ideas on the

compofition of bodies, to thofe that had been already received, muft neceffarily conduce to the difcovery of new means to examine them. It was in confequence of this event that chemifts began to be convinced, that the fluid products obtained in the receivers, by diftillation, were not alone deferving their attention; but that, to gain a more perfect knowledge of the component parts of bodies, it was likewife neceffary to direct their examination towards the volatile and aerial parts, which hitherto had efcaped their obfervation, or, at leaft, had been very little attended to. The knowledge which had been attained by the promoters of the new chemical doctrine, refpecting the compofition of the atmofphere, and the difcovery of new gafes, was the principal means which fome chemifts made ufe of to explain certain facts which occurred from the examination of the blood; and they more particularly applied it in the explanation of the caufe of it's red colour, as well as of feveral other properties that characterize it.

Having determined, pretty exactly, the component parts of the atmofphere, the next circumftance to be attended to, previous to the explanation of the phenomena which the new method of examining bodies offers, was to know how this aerial fluid acted during refpiration, which may be found, in detail, at the article *refpiration.*

During this procefs it was faid that one part of the oxygen, or vital part of the atmofphere, combines with the venous blood, and changes it's colour to a vermilion; a fecond portion of the oxygen unites with the carbon contained in the carbonated hydrogenous gas of the venous blood, and forms carbonic acid gas; a third part unites with the carbon of the mucus of the lungs, and this part, likewife, forms carbonic acid; a fourth

part combines with the hydrogenous gas of the blood, and forms water, which exhales during expiration; with respect to the caloric, which was looked upon as a material ſubſtance, one part of it, which the decompoſed vital air contains, remains united with the oxygen; another part of the caloric enters into combination with the carbonic acid, to form a gas, and the third part produces the temperature to form the water, by the combination of the hydrogen and oxygen gases.

The firſt chemiſt who has enlarged our views on the nature of the blood, and who examined it according to the principles of the new ſyſtem, is Fourcroy. This celebrated chemiſt has opened a new rout on this ſubject, and he begins his inveſtigation at the moment this fluid flows from the veſſels. Fourcroy.

He found that, on agitating pretty briſkly all the parts of the blood, as it comes from the veſſel of an animal, and, for ſome ſhort time after, it's coagulation is prevented; the only ſubſtance that ſeparates is a ſpongy matter, of a flocky appearance, which ſwims on the ſurface. As blood is uſed in ſeveral of the arts, this method is uſed by the butchers previous to their ſelling it.

He found that blood, after having been drawn from the body of the animal, remains at 20° of the thermometer. At the moment of it's coagulation, according to this chemiſt, a quantity of caloric is diſengaged, which, by raiſing the temperature 5°, makes the thermometer be at 25°.

Agitated blood, the principles of which have been prevented from ſeparating, on cooling coagulates at 55° of Reaumur. During this coagulation, a number of air bubbles ſeparate, which remain adhering to the ſide of the veſſel; likewiſe in the internal part a number of cells is obſerved, which muſt have originated from ſome elaſtic fluid that had been diſengaged. This coagulated maſs has an odour and conſiſtence very much reſembling thoſe

of the white of a boiled egg, and is of a grayifh pearl colour. During this coagulation a milky or rather opaline coloured fluid is feparated, which froths very much on agitation, and changes vegetable blues to green.

If this agitated blood be expofed to dephlogifticated air, in a very few hours it becomes of a more lively red than before. A few days after it had acquired a beautiful purple, and on agitation it changed to a beautiful fcarlet red colour. Being ftill expofed, it became of a deep colour like that of the leys of wine, and it was with great difficulty it refumed it's former fcarlet colour by agitation.

The air found to have arifen from it was carbonic acid gas, that had been formed from the carbon of the blood and the oxygen of the vital air. This blood on expofure to hydrogen gas, loft in a few days it's natural colour and brilliancy, and was brown; a few days afterwards it appeared to have feparated into feveral parts by undergoing a decompofition, it had an oily afpect, and it's colour was purple refembling wine leys. Thefe changes are attributed by this chemift to the abforption or difengagement of oxygen.

Exficcated blood being put into a crucible and heated by degrees, it became at firft foftened and confiderably puffed up; there was then extricated a great quantity of very fetid greenifh yellow fumes, this was fucceeded by inflammation, and the flame was white and manifeftly oily. After the oil and ammonia had been formed and difengaged, there was a formation of pruffic acid gas, eafily known by it's odour refembling peach flowers, and it's property of precipitating iron blue. In about fix hours the matter was confumed to four-fifths; it became foftened a fecond time, from the faline and fixed matters it contained; and there arofe upon it's furface a purple flame, accompanied with a very thick fmoke that very ftrongly irritated the eyes and nofe: this was phofphorus in a ftate of combuftion, which had been formed by the action of

the carbon on the phofphoric acid. The refiduum afforded no foda, which blood is known to contain, it having been volatilized by the exceffive heat: but muriat of foda was found, and the oxyd of iron in part reduced, as it was attracted by the magnet; it refembled that from the Ifland of Elba. Exficcated blood diftilled in a retort, to which a pneumatic apparatus was attached, afforded at firft a clear liquid, like water, then carbonic acid gas, and carbonat of ammonia, which appeared on the fides of the glafs in the form of beautiful cryftals; thefe were succeeded by a fluid oil, hydrogen gas, and an oily fubftance of the confiftence of butter.

Befides the exact manner in which this chemift had decompofed blood by heat and collected it's products, whether in a fluid, fixed, or aerial and gafeous form, he made a very important difcovery of the prefence of the bile in it, which he affures us was the cafe. He firft coagulated fome blood by boiling it in diftilled water, and the filtered liquor was of a green colour and odour perfectly analogous to thofe of bile; when evaporated to the confiftence of honey, it's bilious odour became very ftrong, and it's green colour much deeper. On diffolving this extract again in water, it gave it a greenifh colour and the property of frothing very much on agitation. This folution was precipitated by acids and alcohol; the precipitate formed by the laft was gelatin, being foluble in cold water. The precipitation by acids was a real decompofition fimilar to that of bile when treated by thefe reagents. Hence this product of the blood procured by a fimple procefs had all the characters of the bile of the ox, viz. it's odour, colour, bitter naufeous favour, and it's manner of being acted upon by reagents. The difcovery of this fubftance confirms one of the ideas of the ancients on the compofition of the blood. Bile.

It is to the examination of the ferous part of the blood Serum.

to which we are indebted for the difcovery that Fourcroy made of the *gelatin* exifting in this fluid, where Rouelle and the other chemifts had only found albumen, alkali, and neutral falts. The exiftence of jelly in the blood, according to the writings of the ancients, was out of all doubt; but from the properties they attributed to it, it appears they confounded it with the lymphatic matter, which in fome circumftances has really the fame properties. De Haen was fo convinced of jelly in the blood, that he could not conceive how this fluid could be without it, but it was neceffary to give a demonftration of it, and Fourcroy engaged in it.

He found the fpecific gravity of ferum to be eight times greater than water, that it is eafily diffolved by water from zero to the temperature of 50 and 55, at which degree it coagulates. It was alfo coagulated by acids and alcohol, and heat was difengaged at the time. Serum put into a glafs veffel of the thicknefs of one line, and plunged into a bath of diftilled water, coagulated at 60° of Reaumur, the barometer being at 28 inches. When coagulated it was of a light grey colonr, it's confiftence and odour very fimilar to the boiled white of an egg, and had in fome meafure it's favour. During the coagulation a liquor feparates which is flightly turbid, this is *gelatin*; on evaporation, it becomes a trembling mafs. In the blood this liquor is always clear, but in the ferum always fomewhat opake.

Serum when diluted with fix parts of diftilled water was not coagulated by the boiling heat, or by evaporation, to a greater than natural confiftence; but a pretty firm tranfparent pellicle appeared on it's furface resembling that on heated milk, fo well defcribed by Parmentier and Deyeux. Darcet and Scheele likewife knew that the addition of a certain quantity of water prevented the coagulation of ferum by heat. Mixed with half or even with twice it's weight of

water, it coagulates, and on evaporation carbonat of ſoda and marine ſalt are obtained; theſe ſalts it appears are but ſlightly embarraſſed by the portion of gelatin and albumen that remain diſſolved in this water, and when the liquor is ſtrongly evaporated, they ſeparate on cooling.

The circumſtance that appeared to Fourcroy the moſt worthy of being recorded, was his being able to diſcover the cauſe of the coagulation of the albuminous matter by heat. Having obſerved that the white of the egg became thick in proceſs of time by contact with the air; that an egg that had been kept a long time, ſo as to be able to have abſorbed the air, was much ſooner boiled or hardened than a freſh egg; and that the laſt never became ſo hard as an old egg; he concluded that the fixation of oxygen was the cauſe of this coagulation, and that a certain degree of heat was neceſſary to unite the albumen with the oxygen, the ſame as it is neceſſary in the combuſtion of all combuſtible matters, in the oxydation of metals, &c. It was in this manner that the thickening of the lymphatic liquids in the air, the formation of the white, thick, homogenous and concreſcible pus in open wounds, and in ulcers of the lungs which admit the air, had been explained; but a direct experiment was required to remove all objections. Several drachms of ſerum were therefore mixed with an oxyd of quickſilver that had been precipitated by potaſh from the oxygenated muriat of mercury; and it was found that in about 12 hours the oxyd had loſt it's redneſs and was become black or grey, which announced a ſeparation of the oxygen and a reduction of the oxyd, whilſt in proportion as this took place, the ſerum was found to thicken, it was even very hard on it's ſurface, and by agitation the whole became perfectly concrete and ſolid.

Having thus accounted for the coagulation of the albumen, the curioſity of this chemiſt was next directed to

compare the blood of the human fœtus with that of the adult. He remarked that the blood which had been drawn a few hours from the umbilical cord of a newly born infant was coagulated. The ferous part, which was very abundant had a red colour tinged with brown; it fenfibly changed paper ftained with mallows to a green colour; it coagulated at a heat of 55° of Reaumur, the barometer being at 27 inches 8 and $\frac{6}{10}$ lin.; but it was not fo folid as that of the blood of the ox, and a great part of the ferum remained uncoagulated. It was not white when coagulated, but being combined with a certain proportion of colouring matter, this coagulum had a brownifh grey colour. The filtered liquor from this coagulated ferum, diluted with diftilled water, was not fenfibly troubled by lime water, hence Fourcroy concludes that the ferum of the fœtus contains no phofphoric acid.

The coagulum was not fo folid as that of the adult, it was of a deep brown red colour, hence it does not become fo completely red as that of thofe who have refpired; there only appeared to be fome red threads which variegated the furface of the brown mafs, fo that it feemed to be veined with a purple red on a ground of a dark brown. This coagulum well wafhed with diftilled water did not afford $\frac{1}{2}$ of fibrous matter. The wafh expofed to heat coagulated, and the filtered liquor after having been evaporated to 14 fhowed no figns of the prefence of phofphoric acid. From thefe experiments the blood of the human fœtus differs from that of the adult in three remarkable properties: 1ft. It's colouring matter has a deeper fhade, and is not fufceptible of receiving the fplendid purple by the contact of the atmofpheric air; 2d. It contains no fibrous matter concrefcible on cooling, the thick and coagulated portion inftead of it feems rather to approach to the gelatinous matter; 3d. It contains no phofphoric acid. It appears to this chemift, that the

firſt two characters, ſo different from thoſe obſerved in the blood of young people and of adults, manifeſtly ariſe from the fœtus not having reſpired, the contact with the atmoſpheric air not having yet modified the nature of this fluid by the caloric it affords, and by the carbon it abſorbs from it during the act of reſpiration. The great difficulty of procuring this blood in ſufficient quantity prevented this chemiſt from purſuing the comparative experiments he deſired, which are neceſſary to render it's analyſis more exact. To this account of the inveſtigation of the blood may be added the curious fact of this chemiſt having found real native pruſſian blue in the blood of a ſick perſon, which on expoſure to the air aſſumed the brighteſt blue colour. Pruſſian blue in the blood.

Having deſcribed the principal part of the labours of the ancients and moderns on the analyſis of the blood, to the time that Fourcroy placed the nature of this fluid in a new light, we proceed to give the details of the experiments of two of his ſucceſſors, Parmentier and Deyeux, whoſe combined diligence and talents have enriched the ſubject with the moſt intereſting facts and obſervations. Parmentier and Deyeux.

Parmentier and Deyeux commencing their inveſtigation of the blood as it comes from the veſſels, obſerved, that it differs very little at that time from what it is in the living animal, but it ſoon changes it's ſtate, and the firſt alteration is manifeſted by the loſs of it's fluidity, it's heat, it's odour, and it's homogeneity. Firſt changes.

They obſerved that whatever is ſuſceptible of altering the nature and properties of the blood has a ſingular influence on it's aroma or odour. To this may be attributed the more or leſs lively impreſſion a perſon receives from this fluid as it flows from the veſſels, or on entering a butchery, the floor of which is wet with the blood of a newly killed animal. This odour is ſometimes ſo ſtrong as ſcarcely to be ſupported, at leaſt by ſome people, in- Aroma.

ducing a difpofition to fyncope or an inclination to vomit.

Properties of it.

This aroma or odorous principle of the blood had fixed the attention of the chemifts, but the only circumftances known of it were, that it is foluble in water, and that the fluid which holds it in folution changes, and in a fhort time contracts a putrid odour. Prefuming that thefe were not it's only properties, thefe two chemifts endeavoured to inveftigate it further; and they conclude from their experiments that there is no fpirituous or inflamflammable principle connected with the odorous part, as fome authors have pretended; but that the deleterious quality which has been experienced upon refpiring it in large quantity is of a peculiar nature, and effentially different from that produced by mofet and carbonic acid gas; and that the means made ufe of to detect the prefence of thefe laft are infufficient, to eftablifh the properties of the gas that efcapes from the blood. On examining it's nature, they found the affinity of the odorous principle with the atmofphere to be inferior to that which it has for water, and that the laft feized it with great avidity. They look upon it to be a compound body fufceptible of change, that it's alteration is more fudden when affifted by a warm temperature, and that it is at the moment this change takes place that the difagreeable odour is perceived, which is not to be confounded with that which exhales from animal matter the putrefaction of which is complete, becaufe the laft contains ammonia.

In union with atmofpheric air.

With water.

Having examined this odorous principle in combination with the atmofpheric air, they tried it when in folution in water. To procure it in this ftate, they diftilled fome venous blood newly drawn from the ox, on a water bath, and they obtained in the receiver a tranfparent colourlefs fluid, of an odour fimilar to what the blood exhales, and having a difagreeable naufeous favour. This

newly diftilled fluid was not affected by the ordinary reagents. Evaporated on the water bath it left no refiduum, and on being kept for fome time in a well clofed bottle it became putrid, and lightly changed the fyrup of violets green. This odorous water loft it's odour likewife at a degree of heat capable of making it fimmer.

It is likewife foluble in alcohol, but the odour of this liquor is not at firft very marked, it becomes however very evident on diluting it with water. Reagents have no effect upon it. With alcohol.

Thefe chemifts, from the above experiments, are of opinion that this odorous principle of the blood is analogous to the *efprit recteur* of plants, fince both of them affect very fenfibly the organ of fmell, are volatile, are foluble in water and in alcohol, and their folution is not fenfibly acted upon by reagents. The moft remarkable and peculiar property of this odorous principle, is being fubject to a quick decompofition, in which ftate it exhales a difagreeable and fometimes a putrid fmell. They conclude however by obferving that there is a complete analogy between it and other animal fubftances, fince milk, bile, mufcle, the Urine, &c. have each an odorous principle which ferves to diftinguifh them, and the properties of which refemble thofe of the odorous principle of the blood. It is in this aroma that the firft alteration of animal fubftances takes place, to prove which it is only neceffary to obferve what paffes in the air and water which contain this principle in folution. Analogous to the fpiritus rector of plants. With other animal fubftances.

On repeating the experiments of Fourcroy, thefe chemifts found in contradiction to the affertion of that chemift, that blood in a healthy ftate contains no bile, either in it's ferum or coagulum. They allow, however, that it may perhaps be prefent fometimes in difeafed blood, fince it appears from fome phyficians, that the mucous and milky humours are known fuddenly to quit No bile in the blood.

their organs to overwhelm the mafs of blood; at the fame time the numerous contradictions to be met with in books which treat of animal analyfis, often arife from the experiments having been made on the fubftances in very different ftates, which they are known to undergo; an inftance of which is in the urine, for in cold weather the firft alteration in it is that of acefcency, whilft in hot weather it is fcarcely or not at all obferved from the alcalefcency that fucceeds it. This fhows how neceffary it is, in order to obtain fimilar products from fimilar experiments, to have the fubftances upon which they are to be made always in the fame ftate and under the fame circumftances.

Serum. Many phyficians have endeavoured to determine by different experiments the quantity of ferum contained in the blood. Some have pretended that it's quantity is nearly equal to half of the whole mafs that comes from the veins of a healthy fubject; others have affirmed that it forms only three quarters at moft. From the experiments of Parmentier and Deyeux it appears, that the great difficulty of afcertaining this fact, as well as procuring ferum in a ftate proper for chemical analyfis, arifes from the great variations it admits, in it's cohefion with the coagulum. To obtain this ferum pure, *i. e.* with the colour that naturally belongs to it, it is neceffary that the veffel which contains the blood be fet in a place of repofe, at leaft during an hour, as the flighteft motion is able to affect and oppofe the feparation of this part. On repeated examination of the ferum, thefe chemifts found that it contained (as their predeceffors had proved before them) water, albumen, gelatin, neutral falts, and mineral alkali or foda. But it remained to determine, whether thefe fubftances are in a combined ftate, or exift feparately, each of them enjoying their refpective properties. This queftion was the more interefting to determine, as

Rouelle, the only chemiſt that had been any ways ſucceſsful, ſeems to have increaſed the incertitude of it by concluding, that the ſalts, and eſpecially the alkali, were not combined with the other conſtituent parts of the blood. Theſe chemiſts find it difficult to conceive how Rouelle could make ſuch a concluſion, ſince it is unreaſonable to ſuppoſe, that the fixed alkali in the ſerum, together with the gelatin and albumen, can remain by the ſide of theſe two ſubſtances and circulate with them, when experience proves that fixed alkali when mixed with them increaſes their ſolubility.

As a proof of this, if ſome dephlegmated ſpirit of wine be added to freſh ſerum, the mixture will become immediately turbid, and the albumen ſeparated. If very pure alkali be poured on this albumen, it will be diſſolved, and the water with which it ſhall be mixed, will be tranſparent.

To this it may be objected, that the proof of the fixed alkali not being combined with the albumen is, the ſerum changing the ſyrup of violets to a green, a phenomenon which ought not to take place, if the pretended combination exiſted. But it may be anſwered, that there is a combination of the albumen and gelatin with the fixed alkali, in the ſame manner as there is between oils and the alkali; and it is well known that the moſt perfect ſoap has the property of changing the ſyrup of violets green, and nobody certainly can doubt, but that the fixed alkali in the ſoap is combined with the oil.

It may perhaps be ſtill objected, that any analogy between the pretended combination of the albumen in the one caſe, and the ſoap in the other, is ſo much leſs founded, as this laſt matter ſoluble in water is infinitely more ſo in ſpirit of wine, whilſt the ſolution of the albumen by the fixed alkali is not ſoluble in ſpirit of wine, this fluid decompoſing it. To this objection theſe che-

mifts look upon the anfwer to be very eafy. In eftablifhing an analogy between the combination of oil and alkali forming the foap, and the combination of the fixed alkali with the albumen, fuch as they fuppofe it to exift in the ferum, they are far from pretending that thefe two orders of combinations ought to have a perfect refemblance; for it is well known, that in order for the analogy between two bodies compared together to be complete, it is neceffary, that the parts employed in their formation be abfolutely the fame; without this condition there will be always a fenfible difference, which however, in other refpects, will not prevent the exiftence of an evident analogy. Thus for example, if it be faid that the muriatic acid forms a falt with fixed alkali, and that this fame acid likewife forms a falt with calcareous earth; it is not to be fuppofed, that a perfect analogy is intended to be eftablifhed between thefe two falts, fince one of them is always deliquefcent, while the other eafily takes a concrete form: but it is not lefs true that there exifts a fimilitude in the manner in which this acid combines with the alkali and the calcareous earth; hence in this refpect there is an analogy between the two falts. It is the fame refpecting the combination of the albumen with the alkali, fome of the properties of which differ from thofe of the foap only by the conftituent parts of thefe two bodies not being perfectly alike. It therefore appears to be proved, that the fixed alkali found in the ferum is in a ftate of combination with the albumen, and that it does not circulate in the blood in a free and ifolated ftate.

Fixed alkali combined with the albumen.

This, however, cannot be fuppofed to be the cafe with the muriats of foda and of potafh that exift in this fluid. Thefe falts, that have no tendency to combine like the alkali, may be looked upon to be in a difengaged ftate in the ferum, hence it is only with refpect to thefe that the opinion of Rouelle ought to be adopted.

The muriats of foda and of potafh are in a difengaged ftate.

From the very ftrict examination which thefe chemifts made of this albumen, they found that independent of the fixed alkali combined with it, it likewife contains fulphur, and this difcovery is one of the moft curious and important that has yet been made in the analyfis of the blood. Sulphur.

To fhow the prefence of fulphur, the albumen muft be heated in a filver veffel, and being perfectly dry, be made to undergo a degree of heat greater than that of boiling water, when the part of the veffel in contact with the matter will foon be feen to lofe it's metallic fplendour, and become of a black colour, refembling that which fulphur produces when heated upon a filver plate. This fulphur may be obtained apart. For this purpofe, fome of the albumen is to be triturated in a glafs mortar, with a few drops of a well faturated folution of filver; on digefting this mixture a certain time, then heating it after diluting it with water, fome greyifh threads will be obferved, which, by degrees, will become black, and will form at the inferior part of the veffel a precipitate, from which it will be eafy to extract the fulphur in the ordinary way. In fhort, if fixed alkali be boiled with albumen and water, a liquor will be obtained, which being filtered and mixed with diftilled vinegar, exhales an hepatic odour, fufceptible of changing the colour and fplendour of filver. How obtained.

With refpect to the prefence of this fulphur in the ferum, and it's origin, different queftions may occur. Is it the product of animalization, or rather according to thefe chemifts, muft it not be attributed to the decompofition of a body which contained it already formed? Without engaging in any difcuffion that might lead from the principal object, it is only neceffary to obferve, that the albumen of the blood is far from being the only animal matter in which fulphur is to be obtained, fince it

has been extracted from the white of the egg; it is suspected to exist in bile, and it is present in great abundance in the substance of the brain. It appears to these chemists very probable, that the sulphur which is found in the greater part of the animal fluids is as essential to them as their neutral salts, and since it is constantly found in them as well as in serum, it ought to be regarded as one of their constituent parts.

Gelatin.

Of all the parts of the serum, the gelatin which it contains more particularly engaged the attention of these two chemists. It has been before observed, that Fourcroy had made it the object of his examination, but the experiments of this learned chemist being repeated, and only affording insufficient results, new experiments were necessary to procure it in it's perfect state, which was effected in the following manner:—About ten ounces of very pure serum were exposed to the heat of the water-bath in a glass bason, and instead of withdrawing the vessel immediately after coagulation of the lymphatic part, as is the custom, it was permitted to remain for half an hour longer. On examining the matter, it was of a white colour, and the different parts that touched the internal sides of the vessel were strewed with small cells that contained a yellowish matter. On the surface of the coagulated lymph was a thick, yellow, transparent substance, having all the appearance of a jelly; half an ounce of this being separated, and submitted to different experiments, presented the following properties.

Method of obtaining it.

It produced the same effects as glue when taken between the fingers, or extended upon paper; it was of a mild savour, was readily dissolved either by the saliva or by water; the last solution on being exposed to a humid and warm air, soon became covered with a mouldiness; in this state it had a somewhat acid savour, and in time it became putrid. Another portion of this matter, exposed

in a warm place, became dry, and formed on the plate of glafs, where it was extended, a tranfparent layer, as yellow as amber, which on being afterwards diftilled on a naked fire, afforded the fame products as the jelly of hartfhorn. When mixed with cauftic foda, diluted with water, it was foon diffolved, the folution was clear and tranfparent, but on attempting to feparate it, inftead of reappearing in the gelatinous ftate, it was only in the form of white flocks. Having repeated thefe experiments on the ferum of the blood of many animals, thefe chemifts were convinced of the exiftence of gelatin in the blood, and that it forms an effential conftituent part of this fluid.

They likewife obferve, that the gelatin feparated in the above experiment is not the only part that exifts in the blood. They think it more than probable, that another portion is combined with the cauftic foda found in this fluid, by which combination it lofes it's peculiar property of appearing in the form of jelly, and which accounts for it's not reappearing with this property in the ferofity where it is thus diffolved. The gelatin therefore, which is manifeft on the fubftance of the furface of the coagulated albumen is only that, which not having found a fufficient quantity of foda in order to be diffolved, naturally takes the thick confiftence which belongs to it when it is not combined with a foreign body. This mode of reafoning is fupported by the phenomenon obferved on the addition of fome cauftic foda, that had been added to fome ferum: for on heating the mixture, gelatin was no longer obtained, one part of the albumen was alfo diffolved, and the coagulum, inftead of being folid, only became of a foft and pultaceous confiftence.

Part of it in a combined ftate.

It now remains to know, if the foda, the albumen, and gelatin, are in an ifolated ftate, and circulate fo in the blood without being combined; or rather if the combi-

nation of one part of thefe fubftances only takes place when the ferum is coagulated by heat, a circumftance difficult to determine.

Having already proved the exiftence of gelatin in the ferofity, the next thing was to find out if the coagulum, as well as the fibrous matter feparately examined, would equally afford gelatin.

The analogy of the fibrous matter with the mufcular fubftance, gave them reafon at firft to fuppofe that gelatin would be found in it. For this purpofe, one pound of fibrous matter was feparated from the blood of a frefh killed animal by agitation, and boiled for about half an hour in diftilled water. The liquor was then evaporated on the water bath even to three fourths: on cooling, it afforded no jelly, and expofed afterwards to the air in a warm place, it continued to evaporate without fhowing any gelatinous matter.

They were not more fortunate in their examination of the coagulum, from which the ferum had been feparated as much as poffible.

Gelatin only in the ferum.

From thefe experiments, it would appear that the ferum is the only part of the blood that contains gelatin, and that it is in vain to look for it in any other of the component parts.

Differs in different blood.

It was likewife difcovered, that the gelatin is not conftantly the fame in the blood of all animals; in the blood of healthy people it is found to differ both in confiftence, colour, and quantity; and equal differences are obferved in the gelatin of the blood of difeafed people. From the firft obfervations which Parmentier and Deyeux made on this fubject, they were in hopes of finding, that the ftate of the gelatin might be a means of difcovering the nature of the difeafe: but experience foon taught, that they were deceived; for in people labouring under the fame difeafe, fome afforded blood the gelatin of which had a great deal of con-

fiftence and was in large quantity; others blood of which the gelatin was much fofter and in lefs quantity. In fhort, it would feem, that it is with the gelatin as with the fibrin and albumen, which are never identic in all individuals; that their peculiar ftate, their nature, and their quantity, depend on numberlefs circumftances relating to organization, which it is impoffible for the chemift either to appreciate or indicate.

From the preceding experiments, the opinion of Fourcroy on the exiftence of gelatin in the ferum of the blood has therefore been confirmed by thefe chemifts, and there is reafon to believe that this difcovery may be a means of conducting the phyfiologift to the true theory of the formation of the mufcular fibre.

Coagulation of blood.

Blood that is frefh drawn from the vein has it's furface commonly covered with a froth, a great part of which is diffipated as foon as formed. The blood infenfibly lofes in volume, and a thick fubftance is feen to form around the fides of the veffel that contains it, which proceeds to the centre; this confiftence increafes until the whole is in a ftate fimilar to a jelly. When the coagulum is feparated from the ferum in which it fwims, it is tender and eafily divided; internally examined, it prefents a lamellated form, which appears to indicate a fymmetric arrangement; the external part of the coagulum is of a lively red, whilft thofe parts of it not expofed are dark coloured.

Various opinions of it's caufes.

The caufe of the coagulation of the blood, when it is drawn from the veffels, the circumftances that attend, that accelerate, retard and fufpend, or deftroy this coagulation, have given rife to many difputes. It had been attributed to the cold the blood meets with out of the body, but Hewfon proved that this was an erroneous opinion, and the fame has been confirmed by Parmentier and Deyeux; for having received fome blood in two bot-

tles; one was plunged in water heated to 50°, the ſecond in water at zero, and the third expoſed to an atmoſphere at 15°; but the coagulum was formed at the ſame time, and in the ſame manner, in all the bottles.

According to Hunter, the coagulation of the blood takes place, although it be preſerved at a degree of heat equal to that of the animal: that it goes on in the open air, in vacuo, or in a cloſed veſſel. Neither repoſe nor agitation prevents it; and this coagulum abounds in the veſſels neareſt to a gangrenous part. During it's coagulation the blood does not increaſe in temperature, whilſt all other bodies do in paſſing from a fluid to a ſolid ſtate, but reſiſts congelation longer than other bodies, and more ſo the firſt time than afterwards. This phiſiologiſt looks upon the coagulation of the blood to be analogous to the tonic contraction of the muſcles which takes place after death, whilſt the cauſes that deprive the muſcles of this tonic force likewiſe deprive the blood of the power of coagulating. Theſe cauſes are the abſence or preſence of the vital principle.

Not occaſioned by air,

Some have pretended that the air occaſioned the tendency to coagulation, and that if the blood be kept in a veſſel hermetically ſealed, the coagulation does not take place. To verify this aſſertion, Parmentier and Deyeux received ſome blood both from the veins and arteries of an animal into three ſmall glaſs bottles of the ſame ſize; one was cloſed with a ground glaſs ſtopple, the ſecond with cork, and the third was left open; but in all three bottles the coagulation was found to take place in the ſame manner, and at the ſame time.

or by neutral ſalts.

Neutral ſalts, when mixed with blood, oppoſe it's coagulation. This was previouſly ſhown by Hewſon; but ſuſpecting that this effect might be owing to the agitation which he recommends to give the mixture in order to favour the ſolution of the ſalts, about ſix ounces of

blood were received in two flasks, the one of which contained a solution of half an ounce of sulphat of soda, and the other, a solution of the same quantity of muriat of soda; and the effect was, that the mixtures preserved their fluidity, and there was no coagulum to be observed.

In order to find out if it was not the density of the fluid, rather than the action of the different saline matters, that prevented the approaching of the fibrous part, and consequently the formation of the coagulum; some blood was received in two vessels, one of which contained a solution of gum arabic, and the other a solution of starch, but the coagulation took place in both vessels, whether the liquids were hot or cold. Hence it appears, that this coagulation which the blood undergoes is independant of the action of air, heat, cold, or the density of the liquor.

The coagulum, or clot, preserves it's consistence and odour for three, four, or five days, especially when the vessel that contains it exposes but a small surface, and is placed in a fresh place; in a warm temperature, or the contrary, it soon becomes softer, suddenly loses it's consistence, it's colour begins to change, and at last it is extremely fœtid. The coagulum.

If instead of letting the coagulum remain in the serum, it is separated from it, and placed in a warm situation, it becomes dry without suffering any change; in this case, it's colour is of a very deep red, and towards the edges it acquires a semitransparency. If the coagulum separated from the serum be left to drain for the space of half an hour, and be afterwards exposed to the heat of a water-bath, it becomes of a more solid consistence, and the liquor which drops from it is in all it's properties the same as the serum. If the coagulum be put into a certain quantity of boiling water, it gives this fluid a milky hue; there likewise arises at the same time to the surface a Exposed to heat.

ſcum, which is owing to a portion of diſſolved albumen; the coagulum is then of a brown colour and more ſolid.

Alcohol. If the coagulum be digeſted in ſpirit of wine it likewiſe increaſes in conſiſtence; but the ſerum which ſeparates contains no more albumen. On leaving the alcohol to remain on the clot, it only acquires a lemon colour, provided it has been perfectly dephlegmated, and it's mixture with water does not change it's tranſparency.

Water. This is not the caſe with water; this fluid divides the coagulum, becomes red, and remains tranſparent for many days; but it inſenſibly becomes turbid, and there ariſe ſome *membranous pellicles*.

Acids. Acids have more or leſs action upon the coagulum; they all, however, increaſe it's ſolidity by coagulating the albumen which is ſtill contained in the ſerum. To this the nitrous acid is an exception, for it appears to bring about it's diſſolution, whilſt the phoſphoric and ſulphuric acids change it to a black. When the coagulum has been expoſed to the action of the acids, it is no longer ſoluble in water as before, it is only divided by it, by which it's tranſparency is affected.

Alkalis. The carbonats of potaſh and ammonia diſſolve the coagulum. When theſe alkalis are in their pure ſtate (deprived of their carbonic acid) they give it a deep red colour. This ſpecies of ſolution may be preſerved ſome time without becoming putrid or undergoing any change. There is no appearance of thoſe *membranous pellicles*, above-mentioned, ſince it appears, that the alkali, on combining with them, has given them a ſpecies of ſolubility.

Diſtilled. If the coagulum be diſtilled in a retort, it affords the ſame products as other animal ſubſtances, and the carbon which remains, contains iron, ſoda, &c.

On giving an account of the property which water has of diffolving the coagulum, it was obferved, that there always remains behind a *membranous matter* on which this fluid has no action. This is eafily feparated by a very fimple method; it is only neceffary to enclofe the coagulum in a piece of linen, and to rub it between the hands at different times, in a veffel filled with water, when the foluble part will feparate by degrees and leave a refiduum, which is the real fibrous matter of the blood, and which fo many authors have confounded with the coagulable lymph. It is in large quantity. It is moft probable that this fibrin exifts in the coagulum of the blood in a ftate of extreme divifion, and that it only takes the form obferved, on ufing the procefs already defcribed; that is, by the motion imprinted on the coagulum by agitating it in water. This idea appears to be fupported by what is obferved on agitating the blood juft drawn from the vein, when the fibrous matter feparates in large quantity, and adheres to the hands or the inftrument made ufe of to agitate this fluid. Fibrin.

The manner of extracting the fibrin, in the above experiment, appears to Parmentier and Deyeux to be of ufe in explaining the manner in which it feparates fpontaneoufly in the living body. According to the greater part of phyfiologifts, this matter is deftined for the purpofe of forming and repairing the fubftance of the mufcles; if this be the cafe, it may be fuppofed, that the blood, by being in a conftant motion during it's circulation, tends by fuch agitation to deprive itfelf each moment of it's fibrous matter, and to depofit it in greater or lefs quantity, and more or lefs fuddenly according as it's motion is more rapid; whether this be the cafe or not, it is certain, that the fibrin is found entire in the flefhy part of the body, and that when it is feparated from it, it is not fenfibly different from that

which the blood affords that has been agitated on coming from a vein.

Explanation of the coagulation.

It appears, that the influence of this fibrous matter on the formation of the coagulum, or coagulation of the blood, has not been sufficiently attended to by authors. These chemists, however, are of opinion, that the property of the blood to remain fluid, when this matter has been separated from it by agitation or motion, should naturally incline a person to an opinion that it contributed to bring about the concretion of the substance that constitutes the coagulum; and the cause that produces this phenomenon they attempt to explain in the following manner, and which appears to be taken from the explanation previously given of it by Hunter, or greatly resembling it. Whilst the blood remains fluid and homogeneous, it may be considered as being still endued with life or vital motion. The fibrous part it contains, and which is found disseminated through it's whole mass, enjoys a sort of irritability; but in proportion to the distance of time the blood which contains it has been drawn from the vessels, it loses it's motion, in short, it happens at the instant the vital principle entirely leaves it, and it may be considered as in a state of death, that still preserving, during some seconds, the motion of the palpitation of the expiring flesh, it contracts, unites with a part of the matter near it, and retains and communicates to it this state of trembling jelly, the external properties of which have always imposed upon the cause of the real formation of it.

These chemists at first agreed with what several ancient and modern authors had supposed, thar the coagulation of the blood out of the vessels was owing to the cessation of the natural heat; and they were willing to adopt this opinion from observing, that it is principally when this fluid is entirely cool, that the whole mass of

blood is in the form of a coagulum, and in certain refpects to be compared with the jellies of fruits; but the reflection of Hewfon, and further experience, particularly from their frequenting the butchers, changed their opinion, and afforded them no doubt but that the blood in it's feparation and coagulation follows none of the laws attending on cold; but that repofe and motion are the two great means of operating or preventing this decompofition.

Not affected by cold.

But by repofe and motion.

This is fupported by the obfervations of Hewfon, who, on examining the blood as it flowed at different times, found, that the blood which came immediately after the opening of the vein required more time to coagulate than that which he received later. The fame was alfo verified by thefe chemifts, who, on attending the butchers, obferved, that the blood that firft fpouted from the veffels of a beaft was very fluid, but in proportion as thefe veffels lofe their fpring, and the organic action weakens and life efcapes, the blood acquires more confiftence, and flows nearly coagulated or nearly dead when the animal expires: that whatever be the temperature, the coagulation takes place at the fame time, if the motion and action of falts do not interfere immediately to deftroy the vital irritability of the fibrous matter, and kill it; if this laft be the cafe, the blood is only in the form of a liquid, which no means yet known can recal to a ftate of coagulation. In thofe animals whofe blood contains a very large proportion of fibrous matter, it's concretion is made in a very regular and uniform manner; as is the cafe with the blood of the ox, the coagulum of which is only to be divided with nicety in certain directions, and always in the form of lamellæ.

If one or feveral of thefe be feparated from a clot of this kind, all the faline matter may be feparated from them by means of ablution in water, whilft the fibrous

matter, deprived of it's colour, remains alone, repreſenting a maſs of very delicate texture. Such are the ideas of theſe two chemiſts on the formation of the coagulum.

Their experiments were alſo repeated on the blood of many domeſtic animals, ſuch as that of the horſe, ſheep, calf, lamb, and pig, and they found, that this fluid afforded the ſame products in all. It appeared, that only the ſtate of theſe products preſented any very ſenſible difference; for example, the blood of the calf and lamb always afforded a fibrous matter, the texture of which was ſoft when compared to the ox and ſheep. The ſerum likewiſe produced an albuminous matter, which underwent no great degree of coagulation by heat. They found, in general, that the ſtate of health, and vigour of animals, had peculiar influence on the albumen; for on examining the blood of diſeaſed perſons, it often happens, on comparing it with that of healthy individuals of the ſame ſpecies, that very marked differences were to be obſerved in this ſubſtance.

Albumen greatly affected by health and diſeaſe.

Colouring matter.

The next object which theſe chemiſts had in view was the examination of the colouring matter. To obtain it, ſome freſh formed coagulum was put into a linen bag, and waſhed in diſtilled water until the fibrous matter was completely ſeparated. On heating the water of ablution by the water bath, there ſoon aroſe a thick matter of a very deep red colour, which ſwam in the fluid that had previouſly held it diſſolved; this being ſeparated by the filter, and ſtrongly expreſſed to deprive it of all it's humidity, had loſt it's continuity, was eaſily cruſhed, and was reduced to a powder; in this ſtate it had neither odour nor ſavour, and being expoſed to a gentle heat, it became of a very decided black colour.

Acids.

The diluted acids had no action upon it, but when concentrated they decompoſed it, and reduced it to a ſpe-

cies of coal, and this is more effectually done by the afſiſtance of heat.

Fixed and volatile alkalis have very little action on it; but the ſolution inſenſibly takes place when theſe alkalis are in a cauſtic ſtate, and aſſiſted by heat. Alkalis.

Spirit of wine, digeſted on this matter, was not ſenſibly coloured by it. Alcohol.

Vitriolic ether receives a yellow hue from this matter, but ſoon lets it fall down, and only preſerves a ſlight yellowiſh colour, which ſoon leaves it.

The ſame effect takes place when this matter is boiled on a moment in fat oil.

On diſtilling the colouring matter in a retort, it affords products ſimilar to thoſe which the ſerum, fibrous matter, and the whole blood afford when ſubmitted to the ſame proceſs. Diſtilled.

From the above, it appears, that this matter, which has been coagulated by the heat, is only the albumen of the ſerum combined with the colouring part; and it may be readily conceived, that the albuminous matter ought to make part of it's compoſition, ſince it is in the midſt of a fluid filled with albumen that the coagulum is formed, and that this being divided and left to drain, affords a ſerum ſimilar in it's chemical properties to that ſeparated on the formation of the coagulum. To prove this, however, it is neceſſary to iſolate the albumen from the tinging ſubſtance that colours it red; but the experiments which theſe chemiſts made with this view were not ſo ſucceſsful as was expected. Combined with the albumen.

The inſufficiency of chemical means gave reaſon to ſuppoſe at firſt, that the redneſs of the blood was only produced at the inſtant of combination of the body which gave the colour (although not coloured itſelf) with the ſubſtance of the coagulum, in the ſame manner as oxygen when added to lead and mercury in mi-

nium and red precipitate. But this idea of the coloration of the blood was soon abandoned by the chemists; for, on consulting the opinions of different authors, they found that the opinion which attributed the cause to the iron this fluid contained had many partizans, especially since it has been proved, that iron introduced into the animal system in the form of medicine singularly exalted the colour of the blood, and even restored it's colour after it had lost it.

Iron in the blood.

With respect to this metal existing in the blood, chemists have been more occupied in finding it than in determining with precision the state in which it exists; but it's demonstration in this fluid is complete, as appears more particularly from the experiments of Rouelle, Menghini, and Galeati, who limited themselves to one experiment, which proved that fire is absolutely unnecessary to detect it's presence, and that it is sufficient to mix a little powder of nut galls with the blood for it to become in less than 48 hours of a deep black colour. Besides, if the blood be exposed to a heat inferior to that of boiling water, the coagulum pressed and dried in the air gives unequivocal proof to the magnet of the existence of this metal.

It's colour explained by it.

A further examination of the chemical phenomena arising from this subject has given these chemists reason to think, that they have found the solution of the problem of the coloration of the blood, and they explain it in the following manner:

Since iron exists in the blood, it must be either in the state of a metal, an oxyd, or combined with an acid, and consequently in a saline state; or lastly, combined with a body which, without being acid, is capable of forming with it an union, which gives it the property of being soluble in aqueous fluids: and it was upon these grounds that these chemists directed their researches.

Not in metallic state.

They found that iron exists in the blood neither in a

matellic ſtate nor as an oxyd; for on diluting ſome blood with water and preſſing the liquor through a filter, or keeping it in a freſh and tranquil place, they found no iron either on the filter or at the bottom of the veſſel, which ought to have been the caſe from the weight of it's particles; and with reſpect to any martial ſalt being in the blood, the ſoda which exiſts in it would prevent it's formation.

It was on calling to mind the different properties of fixed alkali, and eſpecially that of being able to diſſolve iron under certain circumſtances, that theſe chemiſts think they have diſcovered it to be the real ſolvent of iron in the blood, and that the ſolution of this metal thus effected is the colouring principle of this fluid. In order to explain the ſolution of iron ſuch as it is found in the blood, they ſhow the manner by which a ſimilar ſolution is effected out of it. If a very ſmall portion of iron at a time be put into ſome diluted nitric acid, a ſolution takes place, and when it is perfectly ſaturated fixed alkali may be mixed with it in exceſs, which immediately communicates to the liquor a very deep blood colour. In this caſe the nitric acid in diſſolving the iron is in great part decompoſed; the metal unites to the oxygen, one of the principles of the acid; and it is only after it is well ſaturated with this, that the portion of acid undecompoſed lays hold of and diſſolves it. The alkali being added takes the oxyd of iron from this acid, and inſtead of precipitating combines with it, and it is preciſely at the moment this combination takes place that the red colour appears.

But diſſolved by the ſoda.

Which produces the colour.

The liquor therefore contains two different combinations, the one is nitre, and the other a compoſition formed from the union of the fixed alkali with the oxyd of iron, which combination of alkali with the iron gives it ſolubility. Theſe chemiſts ſuppoſe that a ſimilar combination takes place in the blood, but in order to effect it

nature has no need of employing the nitric acid as an intermedium; any other acid is ſufficient to have diſſolved the iron, ſuch as the phoſphoric, which many chemiſts have proved to exiſt in the blood; or even without admittihg a previous ſolution of the metal in an acid, it is ſufficient that the iron in the blood be properly oxygenated in order that the fixed alkali may be capable of combining with it, and the oxydation of the iron may be conceived, on recollecting the large quantity of oxygen which is introduced into the lungs by means of reſpiration.

As to the quantity of iron in the blood it cannot be doubted, admitting it's ſolution by the fixed alkali, that there is a ſufficiency of it to produce a liquor of a very beautiful red colour. As a proof, however, two ſcruples of iron, the quantity ſuppoſed to have been found in one pound of blood, were diſſolved with ſome fixed alkali, and the ſolution obtained was of a beautiful red, and ſufficiently deep to colour more than one pound of water. The maſs of blood contained in the human body has been valued in different ways, but as it appears from the calculations of many phyſiologiſts that a middle aged healthy perſon requires 25 pounds of blood for exiſtence, it follows from the experiments of Menghini that in ſuch proportion there muſt be 70 ſcruples, or 2 oz. 7 drachms 1 ſcruple of iron. This quantity is certainly very conſiderable, and Menghini is of opinion that ſome future age may ſee nails, ſwords and other inſtruments manufactured from the iron contained in the human blood. If therefore it be added to what is already mentioned, that fixed alkalies and nitre mixed with the blood increaſe it's colour and render it more durable, and that the ſame effect takes place from the ſolution of iron by fixed alkali in the above experiments, it would appear that the opinion of theſe chemiſts on the ſolution of iron in the blood

by fixed alkali, as well as the coloration of this fluid by this fame folution, cannot be looked upon as entirely devoid of probability.

Whatever, however, may be the opinion adopted on the colour of the blood, it is certain that the coagulum is a compofed body, and that the red colour has no influence on it's formation, whilft the oxygen acts a great part in this coloration, for when it is in contact with the blood, the red colour always fenfibly increafes.

It is undoubtedly to the change the blood undergoes by the action of heat, which contracts it on drying, that the difappearance of it's red colour and it's becoming of a deep black, are owing. The iron deprived of the alkali that held it in folution, and a part of the oxygen which conftitutes it an oxyd, changes it's ftate, hence, when feparated by the magnet it is of a different colour to what it was when in a ftate of folution.

Since the explanation of the red colour of blood given by thefe two chemifts, Dr. Wells, in an ingenious memoir in the Philofophical Tranfactions, has made fome experiments and obfervations on the fame fubject. He is of opinion that there is no proof of blood deriving it's colour from iron, and that no other argument has been given in fupport of it, than that the red matter is found to contain that metal. He afferts that there is no neceffary connection between rednefs and iron, fince the fame metal exifts in many bodies of other colours, and even in various parts of animals without colour, as bones and wool, and he gives the following more direct reafons for rejecting the opinion of this metal being the caufe of the red colour.

Dr. Wells of a contrary opinion.

1ft. There is no colour arifing from a metal, that can be permanently deftroyed by expofing it's fubject, in a clofe veffel, to a heat lefs than that of boiling water. But this happens with refpect to the colour of blood.

His reafons.

2d. If the colour from a metal in any ſubſtance be deſtroyed by an alkali, it may be reſtored by the immediate addition of an acid; and the like will happen from the addition of a proper quantity of alkali, if the colour has been deſtroyed by an acid. The colour of blood, on the contrary, when once deſtroyed, either by an acid or an alkali, can never be brought back.

3d. If iron be the cauſe of the red colour of blood, it muſt exiſt there in a ſaline ſtate, ſince the red matter is ſoluble in water. The ſubſtances, therefore, which detect almoſt the ſmalleſt quantity of iron in ſuch a ſtate, ought likewiſe to demonſtrate it's preſence in blood; but upon adding Pruſſian alkali and an infuſion of galls to a very ſaturate ſolution of the red matter, the ſlighteſt blue precipitate could not be obſerved in the former caſe, or that the mixture had acquired the leaſt blue or purple tint, in the latter caſe.

The change of colour by air and neutral ſalts not produced on it's colouring matter.

Dr. Wells likewiſe made ſome experiments to ſhow that the alteration produced upon the colour of blood, both by common air and the neutral ſalts, is independant of any change effected by them upon it's colouring matter; in making theſe experiments he found the following precautions neceſſary.

Precautions neceſſary in making the experiments

1ſt. That the blood ſhould be newly drawn and the weather cool. For as the ſolution of the red matter is not to be filtered, but muſt become tranſparent by the gradual ſubſiding of whatever may render it turbid, if the blood be old, or the weather warm, it will often aſſume before it be clear a dark and purpliſh hue. When expoſed in this ſtate to the atmoſphere in a broad and ſhallow veſſel, it's colour changes to a bright red, which however is not brighter than the proper colour of the ſolution. The dark purpliſh hue ſeems owing to ſome modification of ſulphur, for the ſolution poſſeſſing it ſmells like hepatic air, particularly when agitated, and tarniſhes

ſilver which is held over it. Neutral ſalts produce no change upon this colour.

2d. The neutral ſalts ſhould not be added to the red ſolution, except when perfectly tranſparent, otherwiſe the ſalts will render it more turbid, and the mixture will appear brighter, if ſeen by reflected light.

3d. Laſtly, the red ſolution ought to be poured gently from the veſſel in which it has been made, otherwiſe, as it is a mucilaginous liquor, it is apt to entangle ſmall particles of air, which by acting as opake matter, will for ſome time alter the appearance of the ſolution. With theſe precautions he began his experiments; he infuſed a piece of black craſſamentum of blood in diſtilled water, and immediately covered the veſſel cloſely to prevent any exceſs of air. Having thus obtained a tranſparent ſolution of the red matter nearly free from ſerum and coagulable lymph, he expoſed a quantity of it to the open air, in a ſhallow veſſel, and poured an equal quantity into a ſmall phial, which was then well cloſed. After ſeveral hours the firſt portion was decanted into a veſſel of the ſame ſize and ſhape as that of the ſecond, and having added to it as much diſtilled water as compenſated it's loſs by evaporation, the two were compared together, and were found exactly of the ſame colour. Two other equal quantities of the red ſolution were afterwards poured into two phials of the ſame ſize and ſhape; to one, a little of a ſolution of nitre in water was added, and to the other, as much diſtilled water. On compoſing theſe together their colour was alſo preciſely the ſame. Laſtly, he cut a quantity of dark craſſamentum into thin ſlices, and expoſed them to common air, and when they became fluid, put them into a phial containing diſtilled water. He then took as much of the ſame craſſamentum, which was ſtill black, and infuſed it in an equal quantity of diſtilled water, contained in a phial ſimilar to the former. The two

Experiments.

folutions thus obtained, one from fluid, the other from black blood, were however, of precifely the fame colour. The fame refults were the confequence of repeated experiments.

Affuming, therefore, as proved, that neither common air nor the neutral falts (all thofe which were tried being fimilar to nitre in this refpect) change the colour of the red matter of blood, Dr. Wells attempts to explain the manner in which thofe fubftances give, notwithftanding, to black blood a fluid appearance, which is founded on the theory of Kepler, Zucchius, and Delaval, viz. that the colours of opake bodies do not arife from the rays of light which they reflect from their anterior furfaces, but from that portion of it, which having penetrated their anterior furfaces is reflected by the opake particles which are diffufed through their fubftance.

Explained on the theory of Kepler, &c.

In adapting this theory to the explanation, Dr. Wells firft fuppofes, that all the parts of blood have the fame reflective power. The confequence of which will be, that a mafs fufficiently thick to fuffocate the whole of the light which enters it, before it can proceed to the pofterior furface, and be thence returned through the firft furface, muft appear black; for the rays which are reflected from the firft furface are without colour, and by hypothefis, none can be reflected from it's internal parts. In the next place, let there be difperfed through this black mafs a fmall number of particles, differing from it in reflective power, and it will immediately appear flightly coloured; for fome of the rays, which have penetrated it's furface, will be reflected by thofe particles, and will come to the eye obfcurely tinged with the colour, which is exhibited by a thin layer of blood, when placed between the eye and the light. Increafe now by degrees the number of thofe particles, and in the fame proportion as

they are multiplied, muſt the colour of the maſs become both ſtronger and brighter.

Having thus ſhown that a black maſs may become highly coloured, merely by a conſiderable reflection of light from its internal parts, he thinks, that if he ſhould be able to prove that both common air and the neutral ſalts increaſe the reflection of light from the internal parts of blood, at the ſame time that they brighten it, great progreſs would be made in eſtabliſhing the opinion, that the change of it's appearance occaſioned by them depends upon that circumſtance alone, and the following obſervations he thinks place this point beyond doubt. Owing to an increaſe of the reflection of light by theſe agents.

On comparing ſeveral pieces of craſſamentum, which had been reddened by means of common air and the neutral ſalts, with other pieces of the ſame craſſamentum, that were ſtill black or nearly ſo, he found that the reddened pieces manifeſtly reflected more light than the black. One proof of this was, that the minute parts of the former could be much more diſtinctly ſeen than thoſe of the latter. Now this increaſed reflection of light in the reddened pieces could not ariſe from any change in the reflective power of their ſurfaces, for bodies reflect light from their ſurfaces in proportion to their denſity and inflammability, and neither of thoſe qualities, in the reddened pieces, can be ſuppoſed to have been augmented by common air or a ſolution of a neutral ſalt in water. The increaſed reflection muſt, conſequently, have ariſen from ſome change in their internal parts, by means of which much of the light which had formerly been ſuffocated, was now ſent back through their anterior ſurfaces, tinged with the colour of the medium through which it had paſſed. Proofs.

The preciſe nature of the change of blood by neutral ſalts, Dr Wells thinks is manifeſt by the following experiment. He poured upon a piece of printed card as

much ſerum, rendered very turbid with red globules, as barely allowed the words to be legible through it. He then dropped upon the card a little of the aqueous ſolution of nitre, and obſerved, that wherever the ſolution came in contact with the turbid ſerum, a whitiſh cloud was immediately formed. On ſtirring the two fluids together, the mixture became ſo opake that the printed letters could no longer be ſeen. He has not been able hitherto to deviſe any experiment, which ſhows the exact change induced by common air, but thinks it is evident, that air muſt alſo increaſe in ſome way the opacity of blood, ſince it cannot by any other means increaſe the reflection of light from the interior parts of that body.

The ſame theory explains other facts.

This theory explains another fact reſpecting the colour of blood, which might otherwiſe ſeem unaccountable. If a ſmall quantity of a concentrated mineral acid be applied to a piece of dark craſſamentum, the parts touched by it will for an inſtant appear florid; but the ſame acids added to a ſolution of the red matter in water do nothing more than deſtroy it's colour. On examining the craſſamentum, the cauſe of this difference of effect is diſcovered, for the ſpots upon which the acid was dropped are found covered with whitiſh films. Hence it is evident to Dr. Wells that the acid had occaſioned an increaſe of opacity in the craſſamentum, more quickly than it had deſtroyed it's colour; and that the red matter, from having been in conſequence ſeen by a greater quantity of light, had in that ſhort interval appeared more fluid than formerly.

Converſion of cinnabar into vermilion.

The change which takes place in blood, when it's colour is brightened by common air and the neutral ſalts, is ſimilar to that which occurs to cinnabar, in the making of vermilion. This is made by ſubjecting the cinnabar to a minute mechanical diviſion. But the effect of this diviſion is to interpoſe among it's particles an infi-

nite number of molecules of air, which acting as opake matter, increase the reflection of light from the interior parts of the heap, and occasion all the difference of appearance between these two states of the same body.

Objection answered.

It may be said in opposition, that granting an increased reflection of light from the interior parts of the blood in consequence of air and neutral salts, still this is not a sufficient cause for the production of the colour; for after their action it is a scarlet, which according to Dr. Fordyce differs not only in brightness, but also in kind from the ordinary colour of blood, which is a modena red. The answer is, that there are examples, besides that to which the objection is made, of dark blood appearing florid, merely from it's colouring matter being seen by means of an increased quantity of light. Thus by rubbing a piece of the darkest crassamentum with a proper quantity of serum, the mixture in a few seconds takes a colour similar to that given by common air. But nothing is done but interposing among the red globules a number of the less dense particles of serum, which acting as opake matter increase the internal reflections. Likewise, on viewing by transmitted light the fine edges and angles of a piece of crassamentum in water, their colour appears to be a bright scarlet, though all the other parts of the same mass are black. These facts appear to this chemist to be sufficient to prove what has been already advanced; but he goes a step further, and shows how the modena red is converted into a scarlet.

Appearance of colour.

Blood he found by experiment to be one of those fluids, which Sir Isaac Newton observed to appear yellow when viewed in very thin masses: when therefore a number of opake particles are formed in it by the action of common air and neutral salts, many of them must be situate immediately beneath the surface. The light reflected by these will consequently be yellow, and the whole effect of

the newly-formed opake particles, upon the appearance of the mafs, will be the fame as if yellow had been added to it's former colour, a modena red. But modena red and yellow are the colours which compofe fcarlet.

Origin of the colour.

Upon the whole it appears to Dr. Wells, that blood derives it's colour from the peculiar organization of the animal matter of one of it's parts; for whenever this is deftroyed, the colour difappears, and can never be made to return, which would not be the cafe if it depended upon the prefence of any foreign fubftance whatever.

Mifcellaneous obfervations.

He concludes with feveral mifcellaneous facts refpecting the colour of the blood, and fome confequences that may be derived from them.

Substances that tranfmit air to blood.

It had been mentioned by Dr. Prieftley, that the only animal fluid befide ferum, which he found to tranfmit the influence of common air to blood, was milk. Dr. Wells has obferved that the white of egg, or a folution of fugar in water conveys the influence of air to blood, from which it feems probable that milk owes it's fimilar property to the faccharine matter it contains. Mucilage of gum arabic had no fuch effect.

Neither ferum nor folutions of neutral falts extract colour from blood though they diffolve the red part.

He found (contrary to what had been afferted before) that faturated folutions of all the neutral falts extract, though flowly, red tinctures from blood, fome of which are very deep, and neither they nor ferum, added in any proportion to a folution of the red matter in water, alter it's colour or tranfparency, except by diluting it. For having added a drachm of diftilled water to an ounce of ferum, the mixture was poured upon a fmall piece of craffamentum: and upon an equal piece of this laft a drachm of water was poured, and an ounce of ferum after fome time was added. Each parcel therefore contained the fame quantity of craffamentum, ferum and water, but the craffamentum upon which the mixture of ferum and water had been poured communicated no tinge to it, while the

other piece, to which water had been firſt applied, and afterwards ſerum, gave a deep colour to the fluid above it. Similar experiments were made with craſſamentum, water, and a dilute ſolution of a neutral ſalt, which were attended with the ſame reſults.

Hewſon's obſervations on the red globules confirmed.

Since then neither ſerum, nor a dilute ſolution of a neutral ſalt, will extract colour from blood, though they are both capable of diſſolving the red matter, when ſeparated by water from the other parts of the maſs, it follows, according to this chemiſt, that the red globules conſiſt of two parts, one within the other, and that the outer, being inſoluble in ſerum or dilute ſolutions of neutral ſalts, defends the inner from the action of theſe fluids. The microſcopical obſervations of Hewſon led to the ſame concluſion, that the red globules conſiſt of two parts, an exterior veſicle and an interior ſolid ſphere. The exterior part of the globule appears to Dr. Wells to be that ingredient of the blood upon which common air and the neutral ſalts produce their immediate effect, when they render the whole maſs fluid, for they neither act on the red matter, nor do they occaſion any change in the coagulated lymph or ſerum. It ſeems evident alſo that there exiſts an animal matter in the blood, different from the coagulable lymph, the coagulable part of the ſerum, the putreſcent mucilage and the red particles.

Afford other explanations reſpecting the red globules.

Dr. Wells is of opinion, that although all reaſoning founded upon microſcopical experiments ought perhaps to be regarded as in great meaſure conjectural, yet thoſe of Hewſon appear likewiſe to furniſh a reaſon, why both water and a ſaturate ſolution of a neutral ſalt can extract colour from the red globules, though a mixture of thoſe fluids be incapable of the ſame effect. For water applied to the red globules ſeparates the exterior veſicles from the red particles, which are now open to the action of any ſolvent. The addition however of a ſmall quantity of a

neutral ſalt to the water enables the veſicles to preſerve their ſhape and retain the inner ſphericles. On the addition of a larger quantity of ſalt the veſicles contract, and apply themſelves cloſely to the red particles within. Thus far Hewſon. Let it now be ſuppoſed that the veſicles contract ſtill more, from a further addition of ſalt to the water; then, as the internal particles are incompreſſible, the ſides of the veſicles will be rent, and their contents expoſed to the action of the ſurrounding fluid. Both water, and a ſtrong ſolution of a neutral ſalt, may therefore, according to Dr. Wells, deſtroy the organization of the veſicles, though in different ways, and thus agree in bringing the red matter in contact with a ſolvent, while a mixture of thoſe two fluids, viz. a dilute ſolution of a neutral ſalt, will, by hardening the veſicles, increaſe the defence of the red matter againſt the action of ſolvents.

Extended further by Dr. Wells.

Home.

From the experiments of Charles Grover inſtituted by Home, it appears the blood is capable of uniting with a quantity of urine equal to itſelf, ſo as to form a firm coagulum; that the red particles do not diſſolve in this coagulum, but it is diſſolved by the ſurrounding urine; that an admixture of urine prevents the blood from becoming putrid, and the coagulable lymph breaks down into parts nearly reſembling a ſoft powder. He was led to make theſe experiments from a circumſtance that happened to a patient. He had a rupture of a veſſel in one of the kidneys, and from the ſymptoms, it ſeems, that part of the blood which paſſed into the bladder from the kidney remained there and formed a coagulum, which coagulum gave a bloody tinge to the urine, and cauſed an inability to void it without aſſiſtance, till it was diſſolved by the urine. Experiments out of the body perfectly agreed with what happened in the bladder.

The laſt experiments on healthy blood were made to diſcover the quantity of carbon in it, which was found

to exiſt in larger proportion in the arterial than in venous blood. 1. Abildgaard, on drying 100 parts of the venous blood of a horſe, by a moderate heat got 26 parts of a ſubſtance ſufficiently dry for pulverization, whilſt the ſame quantity of arterial blood afforded 25. 2. To alkalize, after Kirwan's method, 1 oz. of nitre by detonation (480 grains to the oz.) required 192 grains of venous, and only 160 of arterial blood. 3. An oz. of venous blood, after being dried and decompoſed in a cloſe veſſel, afforded 115 $\frac{1}{2}$ grains of carbon, whilſt the ſame quantity of arterial blood only gave 87 $\frac{1}{2}$ of carbon. 4. To decompoſe 480 grains of nitre, 148 grains of carbon of venous blood were neceſſary, but only 119 grains of that of arterial blood: this experiment, however, Abildgaard looked upon as not very exact, from a part of the carbon flying off like a duſt. The carbon of arterial was likewiſe much lighter than that of venous blood. 5. Having ſeparated the red part of the blood from the ſerum and fibrous part, it was dried and tried with nitre, and he found that 130 grains of this red part were neceſſary to alkalize 480 grains of nitre, whilſt it required 202 grains of fibrous part ſeparated from the ſerum, and well waſhed, to alkalize the ſame; this part however detonated with more vivacity than the other parts of the blood. Such are the experiments and obſervations that have been made on the nature and properties of blood in it's healthy ſtate. Abildgaard.

Before the experiments of Parmentier and Deyeux, little or no attempt had been made to determine by analyſis the change that blood undergoes when affected by diſeaſe. The inveſtigation of theſe chemiſts was confined to the human blood, and the ſtandard, by which a compariſon of the products was made, was taken from healthy people of both ſexes, of good conſtitutions, and of different ages and temperaments. They found the blood of a Diſeaſed blood.

young perfon, in general, to have a more lively red colour than that of a middle aged perfon; that the albumen of the ferum does not acquire fo much firmnefs; that the coagulum has lefs confiftence, and that the fibrous matter is not fo abundant: as to the other products, they were fimilar to thofe which the blood of other animals afford; to which it may be added, that no notice was taken of the quantity of the products of different fubjects, but only of the conftituent parts, the comparative quantities varying more or lefs every day in the fame fubject.

In an inflamed ftate. The blood of perfons affected with inflammatory difeafes was firft examined. Some was taken from a young man twenty-fix years old, of a ftrong and vigorous habit: he had been fuddenly feized with a pain in his fide, accompanied with fever, oppreffion, and a fpitting of blood.

This blood, on coming from the vein, was of a beautiful red colour, the coagulum was very foon formed, the ferum feparated from it, and the furface of the coagulum was covered with a whitifh folid *buff*, of the thicknefs of a crown piece, which when it had acquired all it's firmnefs, was feparated from the coagulum. The coagulated part was lefs confiftent than that of healthy blood; it very much refembled red currant jelly, not fufficiently boiled. Water readily diffolved it, and at the fame time fome fibrous particles or pellicles, extremely thin and light, were obferved to remain at the bottom of the veffel, but which foon arofe on the leaft agitation. A part of the coagulum was put into a linen bag, and compreffed at different times in water, by which means the fibrous part was left behind undiffolved in the bag; it was in filaments, the fame as in healthy blood when expofed to the fame procefs. On expofing the water of the lotions to a boiling heat, a thick red coloured matter was feparated, the phyfical properties of which did not appear

to differ from thofe of the fame matter from healthy blood, and it afforded the fame products.

The *buff* (crufta inflammatoria) which covered the furface of the coagulum, being wafhed in diftilled water, became perfectly white, and preferved it's confiftence and thicknefs; after having been wiped with blotting paper, it was fupple and elaftic, and formed an homogenous femitranfparent fubftance, without prefenting any fibrous texture or tearing; it refembled a piece of white fkin that had remained fome time in water. Buff.

It's fpecific gravity was lefs than that of water. Sp. gr.

It was not affected by cold water, but on being digefted in boiling water it refembled flefh in it's being acted upon, and it became hard. Water.

Very diluted acids had fcarcely any effect upon it, but vegetable acids, particularly vinegar, completely diffolved it, and thefe folutions were decompofed by fixed alkalis. Acids.

Fixed and volatile alkalis, in their mild ftate, had very little or no action upon it, but in their cauftic ftate and by digeftion, they diffolved it. Alkalis.

It's exficcation is foon effected by placing it upon the large mouth of a bottle, thus diminifhing it's points of contact: in this fituation, it lofes all it's humidity in the fpace of twenty-four hours, and is reduced to a very thin femitranfparent fubftance, refembling a piece of bladder. Before and after it's exficcation, it affords the fame products as the fibrous matter. Exficcation.

Expofed to a humid air, it foon becomes putrid: it lofes it's confiftence by degrees, and is converted into a kind of puriform matter of fo difgufting an odour as to be difficult to fupport. Putrefaction.

The *ferum*, which, as before mentioned, feparates at the fame time with the coagulum, was of a tranfparent lemon colour; from it's favour it appeared to contain Serum.

fixed alkali, which was corroborated by it's changing the syrup of violets green.

Heat. Boiling water being poured upon it, no coagulation of the albumen took place, but the mixture became of a milky colour, and resembled a solution of soap in water. Exposed to the heat of a water bath (baln. Mar.) it lost it's fluidity, and was converted into a white matter as thick as the hardened white of an egg, however, without entirely it's consistence and continuity, as there appeared to be a small quantity of fluid between it's particles which opposed their union. This matter contained sulphur.

Alkalis. Caustic fixed alkali with this serum formed a mixture that was no longer coagulable by heat; it remained constantly fluid, but on adding some distilled vinegar to it, the liquor became turbid, and a flaky substance separated which swam on it's surface; at the same time, a very sensible odour of sulphurous hydrogenous gas was disengaged.

Acids. Acids likewise do not trouble the transparency of this serum in a diluted state, but they coagulate it when concentrated; this effect is more particularly produced by the sulphuric acid.

Alcohol. This fluid is also acted upon by spirit of wine, for they scarcely come into contact when the mixture becomes turbid and milky.

Distillation. Lastly, if this serum be distilled on the open fire, there are obtained phlegm, oil, fluid, and concrete ammonia; and a light and then a thick heavy oil. Towards the end of the process, the matter tumefies, and at last, a light coal is found at the bottom of the retort, from which iron was extracted by the magnet; afterwards soda and muriat of soda were obtained by lixiviation and spontaneous evaporation.

Compared with healthy blood. Amongst the different products which the analysis of this inflammatory blood afforded, there are some that

prefented characters not to be found in ordinary blood, fuch are

1ft. The buffy matter.

2d. The foft ftate of the coagulum the furface of which was covered by the buff.

3d. The want of continuity of the albumen feparated from the ferum by means of heat.

4th. The impoffibility of producing the concretion of the albumen by pouring boiling water on the ferum.

5th. The milky colour which the mixture receives.

Nature of the buff.

Amongft all the products, the buffy part is one of thofe which appears principally to have fixed the attention of authors who have written on the blood. Having been taught by obfervation, that it only exifted under certain circumftances, it's prefence was looked upon as indicating fome difeafe, but they agreed very little refpecting either it's nature, compofition, properties, or origin. Thus Sydenham attributed it's origin to the lymphatic and fibrous part of the blood. Malpighi and Haller looked upon it as formed by the thickening of the chylous and nutritive matter of the blood. Quefnoy and Sauvages had no doubt of it's being perfectly formed pus, or nearly fo; and Gabert, who had at firft adopted the fame opinion, afterwards abandoned it, and believed it to be one of the albuminous products which feparates from the ferum. Hewfon, Mofcati, and Callifon believed, that it arifes from the craffamentum. They explain it's formation by faying, that the blood, and particularly the coagulable part, is more diffolved and diluted than other blood, on which account the more fpecifically heavy red part has time to feparate and fall to the bottom, whilft the lighter colourlefs part remains at the top; and they conclude, that the action of a real inflammation confifts in a leffened coagulability of the blood. Bordeu and Robert regard it as the product of a fort of mucilage

Various opinions of it.

with which the blood abounds. Hey, Lappenberg, and Burfenius, impute it to an increafed coagulability of the blood, which is partly occafioned by an internal change of it's previous mixture, and a proportionable increafe of the fibrous part to the ferum, and partly to the increafe of the coagulable part of the ferum. Gren likewife attributes it to the increafed coagulability, and the increafe of the fibrous part of the blood. According, however, to de Haen, Siveton, and Boerhaave, the buff is not always prefent in a true inflammation, and it exifts fometimes when this inflammation is not prefent; and Burferius found it in the blood of horfes in their moft perfect health. Such are the diverfity of opinions refpecting this fubftance, but the perfect analogy which the above experiments fhow there is between it and the fibrous matter leaves no doubt on it's nature. It ftill remained to difcover the manner in which the feparation of the buff takes place, which was done in the following manner :—

Separation of the buff. Some blood, in which a buff was expected to form, was received in a porcelane veffel, and every thing about to take place was examined with minute attention. It was obferved, that in proportion as the blood approached towards coagulation, the firft lineaments of the buff began to be formed upon it's furface. By means of a needle fome of this buff was feparated; it appeared in the form of filaments, more or lefs long, their confiftence and elafticity refembling thofe of the fibrous filaments. It was at firft thought poffible that the fame feparation might be continued as the buff appeared, but the coagulation fuddenly taking place, it's furface was covered with a pellicle, which foon became thick and put an end to the experiment; otherwife, the coagulum might have poffibly been procured deprived of it's buff, which would have led to the theory of the formation of that fubftance,

Admitting therefore, that the buff owes it's origin to the fibrous matter; which cannot be doubted, from it's possessing all the properties of that matter; it appears probable to Parmentier and Deveux, that it's formation can only take place, because the particles of the fibrous matter dissolved in the blood, so long as they are endued with vital motion, lose their solubility in proportion as the blood coagulates; afterwards from their specific gravity they rise to the surface, where by uniting, they give rise to the solid body called buff. What appears to justify this explanation, is the facility with which the formation of this substance is prevented, for by separating the fibrous matter by means of agitation, the particles of it not being then able to collect spontaneously together, must necessarily appear under another form; so that, instead of a homogenous substance possessing continuity and a sort of texture, only oblong and elastic filaments are obtained, which are similar in every respect to the fibrous matter. The natural density of the blood that furnishes the buff undoubtedly facilitates the separation of the fibrous matter, and places it in a favourable state that it may collect itself; for when this density is diminished by diluting the blood with water, no buff appears; or if it be formed, it has not the same consistence as that which arises upon the blood when left to itself. Opinion of Parmentier and Deveux.

For the formation therefore of this buff, it is necessary that the blood have a certain degree of fluidity, above and under which the fibrous matter is not able to separate itself; but since this fluidity naturally diminishes in proportion as the blood loses it's vital principle, it is not extraordinary, that a certain quantity of fibrous matter should always remain confounded with the substance of the coagulum, which may be obtained by washing the coagulum in water.

The separation of the fibrous matter employed in form-

ing the buff, may likewife be regarded as the caufe of the foftnefs which, as above mentioned, is natural to the fubftance of the coagulum. Indeed, if, as has been already fhown, the coagulum only owes it's confiftence to the prefence of a certain quantity of fibrous matter, the more inconfiderable the quantity of this matter is, the lefs will be the confiftence of the coagulum; hence it ought to be infinitely more foluble in water than that which is deprived of all it's fibrous matter. In fhort, it would appear, that the fibrous matter, in order to enjoy the property it has of feparating to form the buff, has undergone fome alteration from the action of the difeafe; which, although infenfible to the chemift, is not fo by it's effects in the animal economy during circulation.

Laftly, the fibrous matter is not the only conftituent part of the blood on which the difeafe appears to have acted; it's effects may be likewife remarked in a very fenfible manner on the albumen; for it has been before obferved, that it was coagulated with great difficulty by heat, and that once feparated, it had never that confiftence and continuity which it has when feparated from the ferum of healthy blood by the fame means.

Before concluding this article on inflammatory blood, it may be obferved, that on examining the blood of many patients, affected with inflammatory difeafes, very fenfible differences in the refults are often to be obferved. Sometimes the buffy part is very thick, at other times very thin; fometimes the ferum is in large quantity, at other times in fmall quantity, and feparated from the coagulum with great difficulty; likewife, the blood of different difeafed people has different fhades of colour. From thefe obfervations, the two chemifts have acquired the moft complete proof of the difficulty, or rather impoffibility of finding any two bloods perfectly fimilar;

which is eafily conceived on reflecting upon the diverfity of accidents which, independent of the temperaments of each individual, always accompany inflammatory difeafes, and which have a more or lefs marked influence not only on this fluid, but even on the other fluids of the animal fyftem.

The next object of thefe chemifts, was the inveftigation of the blood of perfons affected with the fcurvy; for this purpofe they examined three patients who had the characteriftic fymptoms of this difeafe. Two of thefe were between twenty-nine and thirty years old, the third was forty-feven. The firft was affected with pains in his fide, independently of the fymptoms of the difeafe, for which venefection was ordered: the fecond, and more particulary the third, had a general plethora, and the expectation of hemorrhage neceffitated the act of V. S. Blood of fcorbutic perfons.

Firft patient. This blood had a red colour with little brightnefs; the coagulum took place very readily, the ferum was flightly lemon-coloured and tranfparent, and the quantity not greater than that of inflammatory blood. It's tafte was alkaline; it changed the fyrup of violets green, mixed with acids without effervefcence, and without lofing it's tranfparency; but it was coagulated by concentrated acids, alcohol, ether, and all dephlegmated fpirituous liquors, which alfo produced a whitifh matter in it that fuddenly fell to the bottom of the veffel; alkalis increafed it's fluidity. Expofed to the heat of boiling water, the ferum coagulated, but not fo firmly as in a healthy ftate; and when this coagulated ferum was flightly preffed, a limpid and colourlefs liquor was obtained, which did not change the fyrup of violets. The matter remaining upon the linen had all the properties of the albumen of the blood.

The coagulum of the blood, a fhort time after it's

formation, loſt a part of it's volume, but at the ſame time a ſmall quantity of ſerum ran from it. It's ſurface did not preſent that lively and bright red froth which is obſerved in healthy blood, but it was covered with ſo thin a pellicle as not to prevent the ſubſtance of the coagulum from being diſtinguiſhed underneath; the tenacity of this pellicle prevented it's being ſeparated. The conſiſtence of the coagulum was the ſame as in ordinary blood, and the fibrous matter ſeparated by means of water, was in as great a quantity, and as firm and elaſtic.

Second patient. The ſeparation took place in this blood as in the preceding; the pellicle that covered it was whitiſh and ſomewhat thick; it's conſiſtence, however, was not very ſtrong, as the leaſt preſſure was ſufficient to tear it. The ſmall portions taken after the ablutions, were white and ſemitranſparent, and reſembled thoſe obtained from the long agitation of a piece of coagulum in cold water: on red-hot coals they were deſtroyed, giving an odour of burnt coal; they were diſſolved by vinegar and cauſtic alkalis; but alcohol, on the contrary, made them ſolid.

The ſerum had nothing in particular.

Third patient. This blood was decidedly buffy, but the buff was not ſo thick as that of inflammatory blood, yet more firm than that of the ſecond patient: it was eaſily waſhed in water without tearing; by waſhing it became very thin, but preſerved it's tranſparency; boiling water, vegetable acids, alkalis and alcohol had the ſame effect upon it as on common buff; on exſiccation it was reduced to ſo friable a leaf as to be divided into ſeveral parts on the leaſt touch. The ſubſtance of the coagulum under this buff had a ſpecies of ſoftneſs which permitted the water to diſſolve it very eaſily, whilſt at the ſame time, ſome membranous pellicles ſeparated from

it, and fell to the bottom of the veffel. This coagulum inclofed in a linen bag, and wafhed with water, afforded, after folution, fome very elaftic fibrous filament.

The ferum, and the red part, coagulated, appeared the fame as thofe of the blood of the two firft patients.

On taking a general view of the blood of the three patients, it was obferved, that none of them had that peculiar odour which is fo marked in healthy blood. This difference in the odorous principle, and a more or lefs difproportion to form buff, are the only effential differences to be obferved in thefe three fcorbutic patients. These chemifts found the defcription of authors, who fay, that the blood of fcorbutic perfons is more fluid than ordinary, not to be true, for it has very nearly the very fame properties as healthy blood; it affords a coagulum of much confiftence, and the quantity of ferum is not more confiderable. They obferved, that if the ferum was greater in quantity from one bleeding, the remainder was lefs voluminous, and *vice verfa*; the confiftence of that which afforded the leaft ferum, lefs firm, whilft on dividing it a quantity of ferum flows out that had been detained between its parts; that the more ferum it affords, the lefs runs from it afterwards; and therefore, if the quantity of ferum of one bleeding be compared with that of another, from the fpontaneous feparation and divifion of the coagulum, very little difference will be perceived; from which it would appear that all indications drawn from the apparent quantity of ferum of the blood, are often erroneous. Obfervations.

The greater or lefs opening in the vein, the greater or lefs confiderable quicknefs with which the blood flows from it, the more or lefs marked weaknefs of the patient, the form of the veffel in which the blood is received, and the motion and agitation which it is fcarcely impoffible to avoid, may be confidered as the principal

caufes which haften or retard the formation of the coagulum, and of it's fometimes retaining a large quantity of ferum; whilft, at other times, it lets a greater or lefs quantity efcape. It is not however to be fuppofed, that in all circumftances the blood of difeafed people is equally ferous; at the fame time, it is an error in thofe phyfiologifts who have advanced, that the fluidity of the blood of fcorbutic people was more decidedly marked than that of the blood obtained in other difeafes.

One reafon of their having attributed this more than ordinary fluidity to fcorbutic blood, appears to have been the facility with which it efcapes from the veffels in that difeafe, and which Parmentier and Deyeux attribute to the debility of the veffels; which not being able to refift the leaft efforts, are eafily torn and let the fluid they contain efcape; hence, the hemorrhages from the gums and nofe of fcorbutic people. The fame happens in old people who are bled; their blood flows flowly, which is attributed to the fame caufe, the debility and flaccidity of the vafcular fyftem; and in many cafes, old people finifh their career by difeafes that are very analogous to the fcurvy. To the fame caufes, *viz.* the veffels being torn, and an extravafation taking place under the fegments, thefe chemifts think, thofe blue fpots originate that are to be feen upon the legs of fcorbutic patients.

Blood of perfons under putrid difeafes.

The laft difeafed blood which Parmentier and Deyeux examined, was that taken from patients affected with putrid fevers. From their experiments it appears, that the blood of thefe patients was never alike. Sometimes the firft bleeding afforded a very buffy blood; at other times the buff was very inconfiderable in quantity, and fometimes it was not prefent; it was likewife to be remarked, that the ferum eafily feparated from the coagulum, although the feparation was oftener more difficult.

The products by analysis presented nothing extraordinary; the buff appeared similar to that in inflammatory diseases; likewise, the substance of the coagulum beneath it had very little consistence, and was very soluble in water, which solution was coagulated by the action of heat, alcohol, and concentrated acids; whilst, on the contrary, fixed and volatile alkalis opposed it's coagulation, and singularly exalted its colour.

It was expected, on submitting it to distillation on the water-bath, that if the principle of putridity really did exist in the blood, proofs of it would be found in the products, such as volatile alkali, which is always obtained from substances in which putridity has taken place; but instead of this, a clear colourless fluid only was obtained, having the odour and light savour of blood, and which had no effect on the syrup of violets. It was also observed, that diseased and healthy blood exposed to the same temperature, was nearly the same time in becoming putrid; from which it is concluded, that in putrid diseases, the principle of putridity does not exist in the blood.

General recapitulation.

On taking a general survey of the experiments, and recapitulating the observations and conclusions of Parmentier and Deyeux, on the nature and analysis of blood, it consists therefore of nine principal parts, *viz.* the odorous part, or aroma. Fibrous matter. Gelatin. Albumen. Red part. Iron. Sulphur. Alkali or soda; and water. The proportion of these parts vary almost infinitely, according to the age, temperament, and the manner of living; all of them having characters that essentially belong to them, with particular shades, which are often difficult to lay hold of.

Aroma.

1st. Odorous part. In the healthy subject, this part is very sensible, especially when the blood is fresh; by degrees it becomes weaker, in proportion to the change

the blood undergoes, and it entirely diſappears when putridity takes place. In the blood of the diſeaſed ſubject, the aroma is leſs decidedly marked; it is even probable, that in certain caſes it is wanting. It appears that it's affinity for the ſerum is leſs than that which it has for the coagulum; for this laſt ſubſtance preſerves it entirely for ſome time; whilſt the ſerum, when perfectly ſeparated, is devoid of it. It ſeems to have a very ſenſible analogy with the aroma of vegetables, ſince both of them, independent of their action upon the organs of ſmell, are ſoluble in water, in air, and in ſpirituous liquors.

Fibrin. 2. Fibrous matter. This matter appears to exiſt in the blood, if not in a ſtate of ſolution, at leaſt in a ſtate of extreme diviſion. To bring about the ſeparation, a rapid motion of this fluid is ſufficient; or it may be obtained by diluting it with a certain quantity of water. In the firſt caſe, the fibrous matter is obtained in the form of filaments, adhering together, and producing a body of ſome elaſticity; in the ſecond caſe, on the contrary, it is precipitated in the form of membranous particles; both of them, however, when treated with chemical agents, afford conſtantly the ſame reſults, that is, thoſe which belong to animal matters in general.

In young animals, the fibrous matter appears to be leſs tenacious in conſiſtence than in the adult, in which the tenacity is more evident; but neither in health nor in diſeaſe is there any other difference than what reſpects the age; ſo that the fibrin ſeparated from the blood of a healthy, vigorous perſon of middle age, very nearly reſembles that of the blood of patients labouring under ſcorbutic, putrid, or inflammatory diſeaſes.

It is the fibrous matter that contributes to the formation of the coagulum, which was a long time attributed to the loſs of the natural heat of the blood; but which

is in reality the consequence of the contraction this matter undergoes on losing the principle of life.

3. Gelatin. Many very celebrated physiologists have suppofed that the blood contained a certain quantity of gelatinous matter. Rouelle and other chemists having sought for it in vain, denied it's existence; Fourcroy however was assured that he had obtained it alone, and disengaged from every foreign body. The aqueous fluids being the natural menstrua of this matter, it may be supposed that the serum would draw it along with it, and it there remains confounded with the albumen, the neutral salts and the soda, but it is easily separated on coagulating the serum. There is therefore no doubt of it's existence. The quantity however of gelatin is very inconsiderable in the blood, and it is perhaps on this account that it's discovery has been so long prevented. It is probable, that in proportion as it is formed, a part of it separates, which is destined with the fibrin to the formation of the muscular substance. The morbific action seems to have no influence on the gelatin, for in the blood of the before-mentioned diseased patients it was found to enjoy all it's properties, and it may be observed on concluding this article, that Hippocrates and Bordeau were not deceived in saying, that the blood was melted and running flesh, since the two matters that constitute flesh are found in this fluid. Gelatin.

4. Albumen. Whilst the blood has not undergone any change, this particular matter remains in solution in the serum, but on the smallest decomposition of the blood it separates into two parts the one of which unites with the serum and gives it a kind of unctuosity; the other on the contrary, joins the fibrin and colouring part. Since then, it's concretion can only take place from the loss of a certain quantity of water that dissolved it, it becomes of Albumen.

confiftence which it partakes of with the two bodies with which it is found mixed.

It is the concretion of the albumen that contributes to the formation of the coagulum by means of the fibrin, and as the concretion of the albumen takes place in this cafe fpontaneoufly and without the aid of heat, it cannot have loft the property of being foluble in a frefh quantity of water; and this is alfo the reafon of the coagulum being entirely foluble in water, whilft the albumen feparated by heat or acids is no longer foluble in aqueous fluids.

The foda or fixed alkali appears to contribute to the folubility of the albumen. Thefe two bodies are indeed in a fort of flight combination, fince heat, fpirit of wine and certain acids are capable of deftroying it, and of caufing the albumen to appear, which immediately lofes the property of being foluble in water.

On comparing the albumen of the blood with that of the white of egg, and of other animal fluids, they are perfectly fimilar, at leaft they have the fame properties, and fulphur is likewife found in them.

Of all the conftituent parts of the blood, the albumen is that which feemed to undergo the greateft alterations from difeafe. In particular it became fenfible on heating the ferum that held it in folution, and it then never acquired that complete concretion which the ferum of healthy blood always had when treated in the fame manner. A certain quantity of liquor feparated, which was eafily extracted by fimple decantation. This change however is not peculiar to any particular diforder, nor could differences be obtained with every precaution, that were fufficiently fenfible to take any account of.

Colouring matter.

5. Red part. This part of the blood varies infinitely in its fhades. In general, the colour of the blood of youth is vermilion, whilft that of old age is darker coloured. It is likewife well known, that venous blood is

of a lefs lively red than arterial, and that the fhades in the colour of this fluid are very numerous. It was impoffible to obtain the colouring part, difengaged of foreign matter, but it appears to be always accompanied with a certain portion of albumen, to which it has a decided relation. Their folubility in water and their infolubility in fpirit of wine, as well as in other menftrua, are the caufes that oppofe their feparation, and prevent the acquirement of the knowledge that might be had of it, if it could be obtained by itfelf. It appears however to be the opinion of Parmentier and Deyeux, that iron acts a great part in the coloration of the blood, and that it's folution is produced in this fluid by the foda.

6. Iron. This metal is only contained in the red part of the blood, which appears from experiments to be held in folution, as obferved, by the alkali, and it is this folution that produces the red colour, but what becomes of the iron on quitting the blood, chemiftry has not yet been able to decide; the moft extraordinary circumftance however, is, that the mufcular part which is fuppofed to be entirely produced by the blood, does not contain the leaft atom of this metal. Iron.

7. Sulphur. It is difficult to determine the ftate in which this fubftance is found in the albumen, but it appears to be one of it's conftituent parts. It moft probably acts a great part in the animal economy, fince independent of what is found in the albumen of the blood, it exifts in the bile, the brain, and in all the humours where albumen is prefent. Sulphur.

8. Fixed alkali or foda. This alkali always accompanies the blood, and is in fufficient quantity always to be eafily obtained from it; moft probably one of it's principal functions is to favour the folution of bodies, which without it's action would remain infoluble, fuch as iron and albumen. It is alfo probable, that it's utility is Soda.

more extenfive, as would appear from it's tendency to combination, and the property it has of communicating it to bodies with which it is found united. It appears to be always in a cauftic ftate, whether in the blood or other humours of the body, and may be confidered as their effential falt. In the blood it more efpecially becomes the *medium junctionis* of the albumen with the ferum, and it's proportion in this fluid is more confiderable than that of the albumen and iron.

Water. 9. Water. The fluidity of the blood effentially depends upon the water it contains, it facilitates the motion of the bodies that conftitute it, and renders them proper to enter into the compofition of the different parts to the formation of which it concurs. If water be compofed of hydrogen and oxygen, it ought to be prefumed, that it is continually forming in the animal fyftem, and that independent of the quantity neceffary to give fluidity to the blood, there is another portion decompofed during the act of circulation, the refults of which decompofition contribute to repair the fuppofed loffes either of the fibrin or albumen.

The blood does not always contain an equal quantity of water, hence it's fluidity is not always the fame; but it is certain, that from it's greater or lefs fluidity, the leaft confequence cannot be drawn, fo as to throw any light on the healthy or morbific ftate of the fubject from whom the blood was drawn, fince from comparative experiments on the blood of both, infinite variations were obferved.

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MILK.

Milk. This is a more or lefs white opake fluid, fecreted from the blood in the breaft of the female fex, for the fupport of their young during the firft ftage of life. The mammalia and cetacea are the only tribes that afford it; on which account they are called lactiferous animals, all others being found deftitute of the organs that fecrete it.

It is remarkable for containing a quantity of faccharine matter in one of it's component parts, and a much greater abundance of the earth of bones or phofphat of lime than any other animal fluid; by which it appears, that nature was defirous of affording a fupply of nourifhment and of offeous matter in proportion to the rapidity of

the formation and increafe of the bones and other parts, during the firft feafon of animal exiftence.

It's proper-ties. Milk, as it is drawn from the animal, has a mild faint fmell, which is peculiar to the fpecies it is taken from. This is the odour that is expreffed by the vulgar faying, it fmells of the cow, the goat, the afs, the fheep, or the mare. As the milk becomes cool, this aroma goes off; it is likewife expelled by expofure to heat.

To the tafte, it is pleafant and more or lefs fweet, and although this laft property is fcarcely perceptible in the milk of fome animals, it is however always mild. To the touch it is fomewhat unctuous.

It's fpecific gravity is greater than that of diftilled water.

When examined by the microfcope, a multitude of globules are feen of unequal fize, and if we may give credit to Leuenhoeck, milk is compofed of tranfparent globules carried in the fame manner as thofe of the blood in a diaphanous liquid.

Spontaneous feparation into three parts. Since tranfparency and limpidity are the moft certain marks of a real folution, it might be expected from the opacity of this fluid, that a portion at leaft of it's contents was only fufpended in it; and fuch is the cafe, for if frefh milk be left to repofe fome time in a cool fituation, a fpontaneous feparation takes place between it's parts. In the firft place, there arifes to the furface a more or lefs thick tenacious fubftance, the *cream*. When this has been taken off, the remainder goes by the name of fkimmed milk; it is then of a bluifh caft, and has a lefs mild favour and is more fluid than before. Some time afterwards, the coagulable or cafeous part of the milk feparates, which is called *curd*. And this feparation is more quickly effected if the atmofphere be warm, by producing a flight acetous fermentation fooner than would otherwife have taken place. When this curd has

been taken from it by filtration, the remaining fluid is called *whey*, or the ferum of milk. The coagulation of milk does not take place in vacuo.

A feparation of the cafeous part, or curd, may likewife be effected artificially by means of chemical reagents; thus milk is coagulated by all acids except the carbonic and weaker acids; by certain vegetables, as galium, vallantia cruciata, madder, thiftle, &c. But according to the obfervation of Jacquin, thefe only act when added to milk in the cold, or when it is mixed with a cold aqueous infufion of them; for if thefe vegetables be boiled in milk, or thrown into hot milk, the coagulation, inftead of being promoted, is rather retarded; nor has the infufion of thefe plants prepared by heat, their decoction, or even their diftilled water any effect upon milk; by mucous bodies, as gum arabic, albumen, fugar, &c.; by all falts, more efpecially if they contain an excefs of acid; as cream of tartar, falts of fuccinum, benzoin, &c. by all metallic folutions; and laftly, by alcohol and all fpirituous liquors, whilft this coagulum is rendered more perfect by means of heat. Artificial feparation by acids, vegetables.

The mild alkalis likewife coagulate milk, but in a different manner from the fubftances before mentioned, for they unite with the butter and cheefe, and form a kind of faponaceous mafs, feparating from the milk in the form of denfe white flocculi, which by continued ebullition become yellow, and at length brown. Alkalis.

The cauftic alkalis diffolve the coagulum or cafeous part, and hence they make milk more fluid inftead of coagulating it.

Lime water produces an imperfect coagulation.

The electric fluid appears to thicken it more or lefs.

Frefh milk neither changes the colour of the tincture of litmus, nor of the fyrup of violets; hence it is neither acid nor alkali.

With refpect to other fubftances mentioned by authors as producing various effects on milk, they will be given when each kind of milk is treated of individually. It may be added, at the fame time, that this fluid is fo fufceptible of variation, not only in different fpecies of animals, but in the fame female at different times, from numberlefs circumftances; fuch as age, feafon, nutriment, &c. that it is almoft impoffible to meet with two milks that do not differ from each other.

Heat at firft renders milk more fluid, and it becomes concrete at the freezing points.

Expofed to heat.

If frefh milk be expofed to a gentle diftilling heat on a water bath, there arifes a fat pellicle, which is fucceeded by others, a part of which being attached to the fides or bottom of the veffel, dries and torrifies, communicating to the fluid a difagreeable empyreumatic tafte and odour, commonly called *potrether*, and which it cannot afterwards be deprived of; it may, however, be prevented by frequent ftirring the fluid; if the ferum is to be obtained, it is neceffary to take away the pellicles as they appear, and replace the fluid in proportion as it evaporates by diftilled water.

The ferum obtained by this method is, on filtration, very clear, and by fpontaneous evaporation affords fugar of milk, and the other falts it held in folution. Thefe pellicles do not form without the contact of the air, fince a combination with oxygen is as neceffary in this cafe as in the fpontaneous coagulation of milk. If thefe pellicles be wafhed, they appear like femipellucid membranes, very much refembling thofe that line the fhells of eggs. They form the cafeous part, and very foon become putrid on expofure to the air.

If the ebullition of the milk be fo accelerated as to prevent the formation of the pellicles, and the products be examined, there is found in the receiver an infipid clear

water, impregnated with the aroma of milk, which ſoon becomes putrid. The part remaining in the retort is either in the ſtate of a moiſt or dry extract, which, when diſſolved in hot water, affords the original milk, but deſtitute of it's peculiar aroma. If this extract be expoſed to a ſtronger degree of heat, as on the ſand bath, it affords an empyreumatic acid and oil, ammonia, and hydrogen and carbonic acid gaſes. The reſiduum in the retort is a black coal, the aſhes of which, on incineration, give potaſh, muriat of potaſh and phoſphat of lime, with a little iron. Extract of milk.

New milk, if left to itſelf, undergoes the acetous fermentation; this in cold weather requires ſeveral days, but in a warm temperature, twenty-four hours are ſufficient for that purpoſe. It appears, that the milk of the ruminating claſs becomes ſour ſooner than that of the others: the milk of the ſheep is ſaid to undergo this fermentation the ſooneſt; and that of the mare, the lateſt. Milks, when rendered ſour, are uſed by different nations as drink or food. Acetous fermentation.

Milk becomes ſuddenly acid from ſudden changes in in the atmoſphere, and from ſtormy ſeaſons, but this propenſity to change may be in ſome meaſure prevented by previous boiling, it will then keep for ſeveral days, but boiled milk, however, ſooner paſſes into the putrid ſtate.

If freſh milk be put into a moderately warm place, and often ſtirred, ſo as to prevent a ſpontaneous ſeparation of it's parts, it undergoes the vinous fermentation, and on diſtillation, a ſtrong ſpirit is obtained; this is ſooner brought about by the addition of a fermenting ſubſtance. According to Stipriaan, the greateſt quantity of ſpirit was obtained from the milk of the cow; whilſt Plenck affirms, the mare, from the greater abundance of ſugar it affords, ferments the ſooneſt. Vinous.

Putrid. There is no animal fluid, if the gastric juice be perhaps excepted, that undergoes the putrid fermentation with so much difficulty as milk: according to Stipriaan, the milk of the cow remained four two months in the middle of summer without any signs of putridity; that of the ass three months before any ammonia was produced; likewise the human milk was kept many months without becoming putrid; hence the difference of nourishment appears to have no influence in this respect.

The next part of this subject that is to be considered, is an examination of the three parts which are the products of spontaneous separation in milk, *viz.* cream, curd and whey.

Cream. *Cream.* This part of the milk which is the lightest, and consequently arises to the surface, contains a fat or oil, which, on being exposed to the air, the mechanical operation of churning, and a certain degree of warmth, is procured in a concrete form called butter; for which *vide* animal oils.

The remaining fluid is white, and is the serum of milk, containing some of the caseous and butyraceous parts; it is sweet or sour according to the sweetness or acidity of the cream employed, and is called *Butter-milk.* According to Stipriaan, the milk of the sheep affords the greatest quantity of cream; then follow the human, and those of the goat and cow, whilst the ass and mare give the smallest quantity. It appears, however, that the cream of the sheep and goat is the thickest; and that from the milk of the human female, of the ass, and of the mare, the thinnest. All bodies which render fat oils soluble in water, impede the separation of butter. The extremes of heat and cold do the same.

Curd. *Curd.* This coagulated part of milk, when fresh, is a white jelly-like substance, somewhat elastic, but is of more or less consistence according as it contains more or

lefs ferum; it breaks readily with a rough fracture; is nearly without fmell or tafte; infoluble in water; becomes hard in hot water; is readily diffolved by acids, forming with the vitriolic and muriatic brown folutions; and with the nitrous acid, a yellow folution; but the marine acid does not diffolve it fo readily as the other two. It is likewife eafily diffolved by the alkalis, pure or carbonated; but the vegetable has the leaft effect upon it. During it's folution with the cauftic mineral alkali, a putrid volatile alkaline fmell arifes.

By diftillation, it affords a taftelefs water that eafily putrifies; on increafing the heat, it blifters, fwells like burnt horn, affords hydrogen and carbonic acid gas, ammonia, partly fixed, partly fluid, and a heavy ftinking empyreumatic oil. The coal is in great quantity, and difficult to incinerate. The afhes contain lime, and phofphat of lime, to which fome chemifts have added iron. Curd or cheefe, on expofure to a ftrong heat, foftens, melts in fome meafure, lofes it's opake white colour, acquires a tranfparency and toughnefs-like horn, throws out more or lefs of it's butyraceous or oily parts, and when cool, become hard and brittle. In fhort, curd has all the properties of albumen.

Curd is of various confiftence in different milks; that of the milk of the goat and cow is folid and elaftic; of the afs and mare lefs folid; that of the fheep only glutinous; whilft the cheefy part of the human milk is never folid, but always fluid, and it's feparation is attended with difficulty, and feldom fpontaneous.

Curd, when falted and compreffed, forms common cheefe. If this be prepared from new milk, containing all it's cream, the cheefe is rich and good; but if from fkimmed milk, which contains but a little butyraceous portion, the cheefe is meagre and bad. In the making of cheefe, fince the coagulation of milk is imperfect by

repofe alone, from the whey ftill containing too many of the cafeous particles; and as the time it takes is long and uncertain, the artificial means of coagulating it have been reforted to. For this purpofe, the moift or dried ftomach of a calf is generally employed, known by the name of rennet. It is the fourth ftomach of the ruminating clafs, and it's power is owing to it's gastric juice, which is fecreted from the middle coat of that organ.

Whey. *Whey.* The ferum of milk, or the fluid that remains after the feparation of the cream and curd, is of a yellowifh colour; has a fweet agreeable tafte; and when the milk has undergone no previous acidity, and prepared without boiling, poffeffes the odour of milk. It is always turbid, and is beft clarified by the white of egg.

Sweet. It is called *fweet whey.* It is fometimes ufed in medicine, and is prepared by adding half a drachm of pulverized cream of tartar, or a few tea fpoonfulls of lemon-juice to a pint of milk, brought to the boiling point, and this is continued until all the cafeous particles are feparated, it is then to be clarified by the white of egg, or deprived of it's fuperabundant acid by a little calcareous earth.

By diftillation of this whey on the water-bath, the fame water is obtained as from new milk, and there remains a mafs, which, when freed from it's cheefy, and other adhering parts, fhoots into white rhomboidal cryftals, termed fugar of milk.

Sour. If, on the contrary, the milk has been previoufly four before coagulation, the liquor that remains is called *four whey.* Sweet whey, likewife by reft, will undergo the acetous fermentation; and we are informed, by Jacquin, that by the addition of a fmall portion of fpirit of wine, and fubfequent fermentation, a true vinegar of milk may be prepared. This acidity of milk is attributed by chemifts to the faccharine part, for they

find that the fooner the whey is become four by fpontaneous fermentation, the fmaller is the quantity of fugar that is left, vide *Lactic acid.*

The fugar of milk is of an opake white colour, has an infipid fweetnefs and fomewhat earthy flavour. It is perfectly foluble in four parts of boiling water. When diftilled by a ftrong heat, it exhibits the fame appearances as common fugar. Rouelle extracted from one pound of this falt when calcined, from twenty-four to thirty grains of afhes; three-fourths of which were muriat of potafh, and the other fourth carbonat of potafh. Placed on a lighted coal the fugar of milk melts, fwells, exhales an odour of fugar candy, and burns like common fugar. Thefe properties induced chemifts to fufpect that, like fugar, it would afford the oxalic acid by means of nitric acid, which Scheele confirmed by experiment; but it required a great deal of nitric acid to obtain it. He procured five drachms of oxalic acid from four ounces of fugar of milk, and he obferved, on diluting with water the refiduum of the fugar of milk treated in this manner, and on filtering it, in order to evaporate and cryftallize the oxalic acid, that a white powder remained on the filter which had rendered the folution turbid; and on examining this acid, he found it to be a peculiar acid, the *faccholactic acid*, for which *vide* Acids. Sugar of milk.

Milk, therefore, from the above analyfis, confifts of the following proximate component parts: a fat oil, an albuminous fubftance, an effential falt and water. Some chemifts, and particularly Macquer and Morveau, have looked upon it as a real animal emulfion, in which the oil is put into a faponaceous ftate by the intervention of the mucous or cafeous part and faline principles; but the neceffity of oxygen in the feparation of the butter and albumen, and the other phyfical properties it poffeffes, are, perhaps, fufficient proofs of milk not being an emul-

ſion. It appears, however, that milk may in ſome meaſure be compared to the juices of expreſſed fruits; it is opake, mild, ſaccharine, nutritive, and contains an eſſential ſalt. Like them, a decompoſition readily takes place, which gives riſe to products analogous to thoſe of wine, *i. e.* an ardent ſpirit and vinegar. It was alſo obſerved by Parmentier and Deyeux, that the thickeſt milk required the longeſt time for the fermentative proceſs to take place; that it furniſhed the greateſt quantity of ardent ſpirit, and that this ſpirit was not evident on diſtillation before the milk has paſſed to the acetous ſtate, which equally happens to cyder, perry, &c. It is to facilitate the fermenteſcible parts becoming acid that the Ruſſian Tartars add a certain quantity of oatmeal to their mares milk, and that they take care not to diſtil it until the mixture is ſtrongly ſour, for by this means they obtain more ſpirit. Milk likewiſe unites a number of properties analogous to the lymphatic and albuminous matter; hence it is employed with advantage to clarify wines, and particularly ratifiats, to which it communicates that marrowy ſavour not to be procured by any other means; for this purpoſe, however, it muſt be freſh, otherwiſe it does harm. It is therefore from it's undergoing the vinous and acetous fermentations, as well as the difficulty of becoming putrid, that milk approaches to the nature of the vegetable kingdom; and from it's containing a quantity of albumen in the caſeous matter, that it reſembles the animal kingdom.

The remote component parts of milk are therefore oxygen, hydrogen, carbon, azot, ſoda, phoſphorus and lime, to which ſome chemiſts have added iron.

HISTORY OF MILK.

It would be in vain to attempt to give any ſatisfactory

account of the firſt knowledge of the component parts of milk, and it's ſpontaneous changes. Milk was undoubtedly made uſe of as an aliment, by the earlieſt inhabitants of antiquity; for hiſtory informs us, that the riches of Abraham and Iſaac conſiſted for the moſt part in their herds. It is likewiſe very evident, that cream, from it's ſo ſoon appearing on the ſurface, muſt have been very early obſerved, and from it's delicious flavour, muſt, no doubt, have been eſteemed a great dainty; but there is reaſon to believe that butter, which forms ſo leading a feature in this fluid, was a much later diſcovery. It is true, that the tranſlators of the bible have made uſe of this word, but the beſt critics are of opinion, that the word *camea* ſignifies milk or cream, or ſour thick milk, and not butter, as it alludes to ſomething liquid. "When I waſhed my ſteps with butter, and the rock poured me out rivers of oil." Job. ch. 29. v. 6. "He ſhall not ſee the rivers, the floods, the brooks of honey and butter." Ibid. ch. 20. v. 17. It is likewiſe the opinion of the learned Michaelis, that the tranſlators of the bible who lived two hundred years after Hippocrates, and reſided in Egypt, and who have tranſlated the word by *Butyron*, meant cream. The oldeſt mention of butter, according to profeſſor Beckmann, though very obſcure, is by Herodotus, in his account of the Scythians. "Theſe people," ſays he, "pour the milk of their mares into wooden veſſels, cauſe it to be violently ſtirred or ſhaken by the blind ſlaves, and ſeparate the part that ariſes to the ſurface, as they conſider it more valuable and delicious than that which is below it." Hippocrates, who was nearly the contemporary of Herodotus, mentions the ſame, but in a much clearer manner.

Cream.

Butter.

"The Scythians pour the milk of their mares into wooden veſſels, and ſhake it violently; this cauſes it to foam, and the fat part which is light riſing to the ſur-

face, becomes what is called butter; the heavy and thick part which is below, being kneaded, and properly prepared, is after being dried called *hippace*. The whey or ſerum remains in the middle." This paſſage, it would ſeem, denotes very clearly butter, cheeſe, and whey. Hippocrates preſcribed it as a medicine under the name of *pikerion*, which becoming obſolete is tranſlated by Galen, *butyron*. The word does not occur in Ariſtotle. In Dioſcorides, we are informed that freſh butter might be melted and poured over pulſe and vegetables inſtead of oil, and employed in paſtry inſtead of other fat ſubſtances. Galen remarks, that cows milk produces the fatteſt butter; that of the goat or ſheep is leſs rich, and that of the aſs yields the pooreſt. Hence butter muſt have been very little uſed or known by the Greeks or Romans in the time of Galen, *i. e.* at the end of the ſecond century. According to Galen and Pliny, the word βουτυρος or βουτυρον is compoſed of βους an ox and τυρος cheeſe; cheeſe was known to them much earlier, and perhaps they may have looked at firſt upon butter as a kind of cheeſe, as τυρος once ſignified, according to Bechmann, any coagulated ſubſtance. The Greeks uſed the milk of ſheep and goats much earlier than cows milk. From what has been ſaid, as well as from other documents, it appears, that butter is neither a Grecian nor a Roman diſcovery, but that the Greeks were made acquainted with it by the Scythians, the Thracians, and the Phrygians; and that the Romans firſt learned it from the people of Germany. It is alſo pretty certain, that when they had been taught the art of making it, it was only employed in their baths, and particularly in medicine; and it may be obſerved, that Columella is the firſt Latin author who uſes the word *butyrum*. The Romans uſed it in general to anoint the bodies of their children, and the ancient Burgundians beſmeared their hair with it. Neither the Greeks nor the

Romans ufed it in cookery, or the preparation of food; they accuftomed themfelves merely to oil, and even at prefent, it is rarely employed in Italy, Spain, Portugal, and the fouthern parts of France, where it is fold in the apothecaries fhops for medicinal purpofes. We may therefore conclude, that the ancients were unacquainted with the method of kneading, wafhing, and falting butter, in order to render it as firm as it is now a days. It was always in an oily ftate and fluid, they always fpeak of fomething liquid; thus the ancients poured it out like oil, and their elephants drank it; but the moderns cut, knead and fpread it.

With refpect to cheefe and whey, we are informed, that cheefe was prepared even from the moft ancient times in Syria, Paleftine, and Egypt, from the milks of the cow, the camel, the goat and the fheep; and that it was a food particularly delightful to the Scythians, and the Greeks; and not only Hippocrates, as before mentioned, but many of the ancients clearly defcribe the ferofity of milk or whey; amongft which are Columella and Diofcorides; they defcribe the method of feparating it by agitation, by coction, or by mixing with the milk vinegar, or the branches of the fig tree; and they likewife give fome account of what they called *oxigala*, which is a preparation formed by the addition of fome falt or more fimply by the mixture of four with frefh milk. In the time, however, of Pliny, it appears, that fome of the barbarous nations living on milk were either ignorant of the benefit of cheefe, or if it was known to them, they difregarded it. Pliny feems to have looked upon this with aftonifhment, for at the fame time, they were accuftomed to thicken their milk into a fort of pleafant four curd like a fyllabub, and as he expreffes himfelf, to churn butter from it, which is the fcum and cream of milk, and much thicker in confiftence than the whey. We

Cheefe and Whey.

are informed by this celebrated Roman author and natural hiſtorian, that the milk which is afforded by thoſe animals that have teeth in both jaws is not fit to make cheeſe, becauſe it will not curdle. This has been certified by the beſt chemiſts of modern days with reſpect to that of the human female, which is in general found incapable of coagulation, although it has been denied by others. Pliny likewiſe informs us that the milk of the cow affords more cheeſe than that of the goat, being nearly twice as much; and that at Rome, the beſt cheeſes came from the provinces of Nemauſium, and from the villages of Læſo and Baux, but that it was neceſſary to eat them green. Excellent cheeſe was likewiſe made in Dalmatia, Drinaldi, and Vatuſium, in the province of Ceutonia, and in the Sæditian territory. In his days, the beſt foreign cheeſe came from Bithynia, whilſt that ſent from France had a phyſicky taſte and a kind of aromatic ſavour. With reſpect to any other knowledge the ancients had of the other component parts of this fluid, it was perhaps only a ſuperficial acquaintance with the ſaccharine part, and limited to the organs of taſte.

State of analyſis of milk in the middle of the laſt century.

The analyſis of milk ſeems to have been but very imperfectly underſtood towards the middle of the laſt century. Swammerdam and Leuwenhoeck had examined it's globules by the microſcope; it was known that warmth aſſiſted in it's coagulation, and that in tempeſtuous weather it became ſour much ſooner than in calm ſeaſons; that this took place more readily in ruminating than non-ruminating animals, and that the milk of the carnivorous claſs, when fed entirely on fleſh, was not coagulated at all. Homberg, Boerhaave, du Hamel, Rutty, Navier, Egeling, Geymuller, and Wulliamoz, had made ſome obſervations and a few experiments upon it; it's coagulation by acids, by alcohol, by alum, was known; the ſpecific gravity of the different milks had been examined,

the quantities of the cream, butter, and cheefe they contained, in fome meafure afcertained; it had been fubjected to the power of caloric, and from it, on diftillation, we are informed, much water was obtained; this was rather empyreumatic, an acid fpirit afterwards, a fetid oil, and a fplendid friable coal remained at laft, in which was a fixed falt. Butter and cheefe had likewife undergone a flight examination; an acid water with the butyraceous odour, a thick fluid oil, and another kind that was tenacious and red, were faid to have been produced from the firft, and on the incineration of the coal, a fixed alkali was obtained which was fuppofed to be the vegetable; the fecond, or cafeous part, was faid to be of a mucilaginous nature, that it gives an acid phlegm, a bluifh oil, fomewhat empyreumatic, then thick, black, and fo weighty as to fink in water, and that the coal is afterward difficult of incineration. It was thought that the cafeous part was the moft powerfully nourifhing of the milk; that the oily or butyraceous part had a laxative property, and that the aqueous part was of a refrigerating nature; with refpect to the ferum of milk, or it's whey, it had been long known that it contained a faccharine part, which was faid to be of an animal nature. This had been firft mentioned by Fabricius Bartolettus, and afterward defcribed by Lewis Jefti, though the Brachmans had been before accuftomed to procure it from milk, as well as other fweet juices. Navier had extracted it from the human milk, and Hoffmann from that of the afs.

Very foon after this period, more numerous experiments were made to procure a more exact analyfis of milk; it's phyfical properties were better defined, and the action of reagents on different fpecies of it, were more fuccefsfully inveftigated by Geoffroy, Bergius, Voltelen, Spielmann, Scheele, &c. a few of which

it will be neceſſary to mention, without going into any extenſive detail. With reſpect to the quantities of cream, cheeſe, whey, and the butyraceous parts of different milks, Spielmann has examined thoſe of the human, the goat, the ſheep, and the cow; he informs us, that two pounds of the firſt contained one ounce and a half of cream, which afforded ſix drachms of butter, half an ounce of a tender cheeſe, and ten drachms of a fixed matter which remained after inſpiſſation of the whey; the reſt was water. From the ſame quantity of the milk of the goat, he obtained one ounce of cream, three drachms of butter, three ounces and three drachms of cheeſe, and ſix drachms of a fixed matter; hence it contained more cheeſe, and leſs water and oil than the human. The ſame quantity of ſheep's milk afforded him two ounces of cream, fourteen drachms of ſoft butter, four ounces of cheeſe, and ten drachms of fixed matter; hence he found it to be fatter and more caſeous than the human, but not ſo thin. From the ſame quantity of cows milk he procured three ounces and half of cream, ſix drachms of hardiſh butter, three ounces of cheeſe, eleven drachms of fixed matter; hence it exceeded the human by far, both in butter and cheeſe. He found the milk of the aſs to be the heavieſt, and that of the goat the lighteſt.

Spielmann.

According to Voltelen's experiments, thirty ounces of human milk afforded him only two drachms of cream. The ſame quantity of aſſes milk gave him only three drachms of cream, but no butter, three drachms of tender cheeſe, an ounce and half of a fixed matter on inſpiſſation; and he found it contained more fixed part and water, and to be leſs rich in butter and cheſe than the human milk. Two pounds of mare's milk afforded three drachms of cream, no butter, ſeventeen drachms of cheeſe, and

Voltelen.

nine of fixed matter; which is, therefore, richer in the laſt matter, but contains leſs oil and water than the human milk.

With reſpect to the ſpontaneous acidity of milk, that of the human, which is ſaid to afford more cream in a ſhorter time than any other, is not ſubject to this fermentation, if the perſon has been accuſtomed to fleſh diet; for, according to Bergius, ſome of it, after having been placed in a heated oven for many weeks, and being covered with a very thick cream, had contracted not the ſlighteſt acidity. On the contrary, we are informed, that when the perſon fed only on a vegetable diet, it coagulated on the eighth day, whilſt that of the cow becomes acid in three days and a half. Bergius.

With reſpect to the coagulation of milk by *acids*, according to Voltelen, the three mineral acids, as well as aqua regia and vinegar, ſoon coagulate ſheep's milk in the cold; but cream of tartar coagulates it more ſlowly. He found that aſſes milk is coagulated by vinegar, cream of tartar, ſpirit of ſulphur, aqua regia, nitrous and vitriolic acids, in the cold; and that rennet from the calf, and ſmoking muriatic acid, required the aſſiſtance of heat: that human milk was neither coagulated at it's natural temperature, nor in the cold, by lemon juice, cream of tartar, rennet, ſpirit of vitriol, nor by the three ſtrong mineral acids; on the contrary, in a boiling heat, a yellow porous coagulum was ſeparated from it by the nitrous acid, and a thick white one by the muriatic; the firſt of which, on digeſtion with nitrous acid, became of a bluiſh and bluiſh-grey colour; the other remained unchanged; whilſt, according to Bergius, it became coagulable by vinegar, after the perſon had lived on vegetable diet, which muſt be continued at leaſt eight days. According to Scheele, the Acids.

vegetable acids produce more cheeſe from cow's milk than the mineral.

Scopoli obtained from one ounce of cow's milk, coagulated by vitriolic acid, ſeventy grains of reddiſh coagulum, and on filtration, a perfectly tranſparent whey; with muriatic acid, 51 grains of the firſt, and the whey not quite ſo tranſparent; with nitrous acid, 46 grains of yellow coagulum and turbid whey; with acid of arſenic, 61 grains of whitiſh coagulum, and the whey evidently tranſparent; with fluor acid, 40 grains of the ſame, and a ſimilar whey, which, however, depoſited a yellow coagulum; with phoſphoric acid, 40 grains of white coagulum, and ſome clear whey, from which a little more coagulum fell to the bottom; with acid of ſugar, 43 grains of whitiſh coagulum and turbid whey, which ſtill depoſited ſome coagulum; with acid of tartar, 48 grains of the ſame, without ſediment; with animal acid, 25 grains of the ſame, which on repoſe depoſited more; with the acid of wood, 28 grains of whitiſh coagulum, and turbid whey; with vinegar 36 grains of reddiſh coagulum, and clear whey, with ſome little coagulated depoſit; and laſtly, with lemon acid, 40 grains of yellowiſh coagulum and turbid whey, from which ſome more coagulum ſeparated.

Alkalis. With reſpect to *alkalis*, we are informed by Egeling, that cow's milk is coagulated either by fixed or volatile alkalis.

Scopoli obtained from one ounce of cow's milk mixed with mild vegetable alkali, forty-eight grains of white coagulum and turbid whey; with cauſtic volatile alkali, forty-ſix grains of yellowiſh coagulum and turbid milk, which, after filtration, ſeparated more coagulum; and with mild volatile alkali twenty-four grains of white coagulum and turbid whey. According to Morgagni, lime water does not coagulate cow's milk. According

to Voltelen, ſheep's milk is not coagulated by cauſtic volatile alkali; by cauſtic fixed alkalis and lixivium ſanguinis only by heat; but by common, fixed, and volatile alkalis, light flocks are produced in it; and by a boiling heat, larger flocks. Mixed with lime water, both in heat and cold, it remains unchanged. From aſſes milk, cauſtic volatile alkaline ſpirit, produced only extremely ſmall flocks; the common volatile alkali in the cold, ſomewhat larger; ſoap lees had a leſs effect; lixivium ſanguinis, and much ſooner common alkali, afforded thick lumps of coagulum; lime-water had no action upon it, but by no means prevented it's coagulation by acids and rennet.

According to Bergius, the human milk was neither changed in it's natural temperament, nor at a boiling heat by ſpirits of hartſhorn, volatile alkali, nor by ſpirit of ſal ammoniac; nor by oil of tartar, or fixed alkali, either in it's common temperature or in the cold; mixed, however, with it at a boiling heat, and digeſted, they changed it's colour to a yellowiſh green, which gave immediate riſe to a thick pellicle, and an odour of ſweet cheeſe. Nor was this milk changed by ſoap lees in the warmth, from Voltelen's experiment; but lixiv. ſang. although it did not coagulate in the cold, yet by a boiling heat produced a ſtrong coagulation, with an evident change of colour. By the ſame heat it was coagulated by lime water. We likewiſe are informed by Voltelen, that the human milk, the ſheep's, and the aſſes milk, and the cows milk, according to Boerhaave, on being boiled with fixed alkalis, become by degrees more yellow, afterwards reddiſh, and at laſt blood-coloured, brown red, and dark red. After ſome time ſmall flocks are ſeparated from this red fluid, which is covered with cream, and this takes place immediately if vitriolic acid be added. The human milk, when boiled with lixiv. ſang.

deposits a caseous matter in forty-eight hours, whilst a yellowish red tough pellicle is formed on it's surface. and the fluid itself is darkish. According to Silvius's conjecture, it was by such means that the conversion of chyle into blood was brought about.

According to Voltelen, the human, cows, sheep's, and asses milk, neither in the cold nor by heat, are acted upon by solutions of saline neutral salts, such as vitriolated tartar, nitre, common salt, sal ammon. spiritus, Minder. nor by borax. It, however, appears, that sal ammon. promotes the separation of the cream and whey in the milk of the sheep, and that common salt coagulates milk, although Gourraigne affirms, that it prevents the coagulation of it by acids. With respect to the earthy neutral salts, bitter salt has no effect upon milk. According to Voltelen, alum has no effect on human milk, either in the cold, or with the assistance of heat; but decomposes that of the ass and the sheep when boiled with it.

Neutral.

The same chemist informs us, that most of the metallic solutions decompose the different sorts of milk, in a longer or shorter space of time: that solutions of iron and it's vitriol act upon them in the cold: that sugar of lead, which decomposes asses and sheep's milk immediately in the cold, appears only to hasten the separation of the cream in the human milk: that the vitriolic and nitrous solutions of quicksilver produce a quick coagulation and a red colour. The solution of corrosive sublimate coagulates them in the warmth. The acid solution of copper, decomposes asses and sheep's milk, but only colours human milk, and the volatile alkaline solution of copper has no effect in coagulating milk of any species. A solution of silver coagulates milk, and colours the whey, first of a rose colour, then of a purple red. We are informed by Navier, that arsenic appears to pre-

Metallic solutions.

vent the coagulation of milk. Voltelen likewiſe informs us, that aſſes milk was not coagulated by the mercurius gummoſus of Plenck, in the cold, but was very ſtrongly ſo by the aſſiſtance of heat; this, however, is ſuppoſed to have ariſen from the gum, which, according to Scheele, as well as the albumen of the egg and ſugar, coagulates milk.

According to Leonhardi, the human milk mixed with alcohol, at firſt did not coagulate, but began in about twenty-four hours, by the means of heat. The alcohol had no effect on the milk, when ſedative ſalt or camphor was diſſolved in it; on the contrary, the alcohol coagulated aſſes milk a little ~~in the~~ cold, and ſheep's milk very ſtrongly. With ſpiritus camphori, both the kinds of milk undergo no change; camphor even appeared to prevent their coagulation. Alcohol.

Scopoli obtained by alcohol, twenty-five grains of white coagulum, and the filtrated whey was afterwards milk white.

The aſtringent vegetables decompoſe in the cold, the human milk, and thoſe of the cow, the aſs, and ſheep. According to Scheele, the ſame effect takes place with the Peruvian bark. According to Bergius, human milk is neither coagulated by ſaliva, nor bile, nor by the white of eggs.

With reſpect to the beſt methods of coagulating milk, ſo as to procure the whey as pure as poſſible, we are informed by Frederick Hoffmann, that ſour whey, (ſerum lactis acidulum) is procured by adding one drachm of cream of tartar, or one or two tea-ſpoonfuls of lemon juice to one pound of boiling milk, and to keep it boiling afterwards until the caſeous part is perfectly ſeparated. It is then to be clarified with the white of eggs, filtrated, and edulcorated by the powder of crabs-eyes. Coagulation of milk.

Vinous milk (ſerum lactis vinoſum) is prepared by

adding four or fix ounces of good four white wine to a meafure of boiling milk, and after coagulation filtrating the liquor.

Another kind of whey, called *doppelmolken* by the Germans, (ferum lactis duplicatum) is obtained by equal parts of frefh milk and butter milk, being mixed together when warm.

According to Pœrner, it is much better for the cheefe and the whey, to coagulate milk by rennet; by this means he obtained the beft and fweeteft whey, and it afforded a greater quantity in general, than when cream of tartar or lemon juice was ufed. If either of the laft fubftances be employed, it is neceffary to add crabs eyes, or a fimilar fubftance, to the four whey obtained, to edulcorate it, which give it an unpleafant earthy tafte. Befides, fome part is diffolved by the acid which remains after filtration. Pœrner, therefore, gives the preference to rennet, which may be prepared in different manners, of which he mentions two. The ftomach of a fucking calf being blown up whilft the coagulated milk remains in it, it is gradually dried; the two ends are then to be cut off, the coagulated milk, which is nearly dried, muft be thrown away, and only the ftomach employed, of which a piece about a finger's length is to be cut off when required, put into a glafs, and three or four fpoonfuls of frefh water added to it, in which it is to remain from fixteen to twenty-four hours. A fpoonful of this is then to be taken, and mixed with a kanne of the fkimmed milk to be coagulated; it is then placed on a moderate fire, fo as to be made warm until it is coagulated, which takes place in a quarter, or at fartheft half an hour. It is then to be filtrated, and the whey is very pleafant and not acid. The other method is to take the frefh ftomach of a fucking calf, cleanfe it, put the coagulated milk in again, add a little common falt, and fill the ftomach half

full of milk. Having tied the two ends, it is to be placed in a bafin and more milk added to it, a little more falt added, and to be left to repofe a couple of days in a moderately warm place; which, according to Leonhardi, ought to be from 70° to 100° of Fahrenheit. Of the milk which has now become coagulated in the bafin, a fpoonful is to be taken and ufed as before mentioned. When this is confumed, the ftomach is to be opened to let a little run out, tied again, and the bafin filled as before with milk, and covered. By this means a ftomach will laft nearly a year; care muft, however, be taken that it become not putrid. Hence it appears, that Pœrner, as well as Macquer, was of opinion that the coagulation proceeded from the coagulated milk of the ftomach, and that the caufe of this was an acid. It is fcarcely neceffary to mention, that the coagulation is now well known to be caufed by the gaftric juice, and that the ftomach is ufed in a dry ftate.

According to Macquer, whey is not only the aqueous part of the milk, but contains likewife all the component parts of it which are foluble in water. It has a peculiar tafte, which becomes ftronger on evaporation. This favour is fomewhat faccharine and faline. It contains an extractive faccharine matter, and hence is capable of the fpirituous fermentation. It alfo contains other kinds of falts, which are mentioned by Leonhardi, fuch as the vegetable alkali, the acid of milk, phofphat of lime, and digeftive falt.

According to Boerhaave, the water which comes out on the diftillation of milk is fomewhat empyreumatic and naufeating to the tafte. Voltelen found this water of the fame fmell as the milk, and mild in favour, but unpleafant. Befides this water which he obtained from the diftillation of the human, affes, and fheep's milk he obtained an acid fpirit, a light and heavy oil; and in the

Diftillation of milk.

affes, after incinerating the coal, a fixed alkaline falt, a fort of neutral common falt, an earthy fubftance, and fome particles of iron. He likewife obferved in the diftillation of the milks of the afs and fheep, that a real volatile alkali arofe after the acid fpirit. Beccaria had obferved the prefence of this alkali in milk, and Hahn had obferved it in that of the cow; but in Voltelen's experiments, there were no traces of it in the human milk. From the laft milk, however, there was extricated a very large quantity of an elaftic gafeous matter even during the coming over of the water, which at times threatened to break the veffel, of this air he did not find any in the two other milks.

Sugar of milk. It is related by Kempfer, that the Brachmans were acquainted with the procefs of making the fugar of milk: Bartholdi. whether this was the cafe or not, Fabricius Bartholdi, an Italian phyfician, is the firft who has mentioned this effential faccharine fubftance of milk in his Encyclopædia, printed at Bologna in 1619, under the title of Manna; or Nitre of Milk: and it is from this book that Etmuller Tefti. has borrowed his defcription of it. In 1698, Tefti, a Venetian phyfician, publifhed a Memoir of the Sugar of Milk, in which he appears to attribute the difcovery of it to himfelf: he fpeaks with great zeal of it's medical virtues, particularly in the cure of the gout, and in an alchemical ftyle defcribes the method of preparing it. Different accounts of the fame fort have been given by Werlofchnigg, Vallifnieri, Fickius and Cartheufer. We Wulliamoz. are informed by Wulliamoz, that the manner in which Cartheufer prepared it did not fucceed with him; he praifes in the higheft ftyle the fugar of milk prepared by one Creuzius, and efteems it the beft mode of any which the Swifs make ufe of, and which he regrets is not underftood elfewhere. It is known that in Switzerland this fugar has long been made a part of their traffic; they

fell two forts of it, one in the form of tablets, the other in that of cryftals. He has given us the method employed in the Alps for making both varieties. For the firft, the milk muft be previoufly fkimmed, it is then coagulated by rennet, filtrated through a linen cloth, and the whey evaporated over a flow fire to the confiftence of honey; when it is fufficiently thickened, it is put into moulds of different figures and dried in the fun. For the fecond, thefe tablets are diffolved in water, clarified with the white of eggs, then filtrated and evaporated to the confiftence of fyrup, and left in repofe to cryftallize. Thefe cryftals, on examination, are found to be compofed of cubic maffes, very brilliant and white, and are attached to the fides of the veffel in ftrata; if the remaining liquor be again expofed to heat, and evaporated, other cryftals are obtained on evaporation, and this operation may be feparated a third time. The firft cryftals are of a dazzling white, the fecond of the colour of ftraw, and the laft of a bran colour; thefe by folution, clarification, filtration, and cryftallization, may be brought to the fame dazzling whitenefs and degree of purity as the firft. According to Wulliamoz, the properties which he found the fugar of milk to poffefs, and the products it afforded him on decompofition, prove it to be of a faponaceous nature; it unites oils with water, and it has a great refemblance to the juice of the fugar cane.

Haller has, according to Morveau, given the beft method of preparing the fugar of milk. The whey is to be clarified with the whites of eggs, and continually kept boiling until that part is feparated, in order to thicken it before it has contracted any acidity. The cryftals are then neither acid nor alcaline, but an effential falt as perfect as the fugar of the cane, which like it renders oils mifcible with water, prevents the cream feparating from the milk, and in fhort has the properties of foap. Haller Haller.

believes that the milk of all animals contains this ſalt, but not in the ſame proportions. According to his account, four ounces of ſheep's milk afforded from 35 to 37 gr^{s}. of ſugar.

Goats	47—49
Cows	53—54
Human	58—67
Mares	69—70
Aſſes	80—82

Lichtenſtein. Lichtenſtein has examined and analyſed the different ſugars of milk, which are ſold at various prices in Switzerland, and has more particularly diſtinguiſhed ſix ſpecies, of which an account will be given. He extracted this ſugar both from ſweet and ſour whey; he found that the reſidue of the ſaccharine cryſtallization, or what remains after the cryſtallization of the ſugar of milk in *ſweet* whey, is pituitous, ſomewhat empyreumatic, and taſtes ſaline; that it is eaſily diſſolved in water, changes the ſyrup of violets, tincture of litmus, and the ſolution of Brunſwick, green. When mixed with liver of ſulphur, no ſtrong ſmell ariſes; rubbed with fixed alkalies, unſlacked lime or minium, it gives a volatile alkaline ſmell; and mixed with vitriolic acid, a ſmell of muriatic acid; it gives a precipitate of luna cornea when mixed with the ſolution of ſilver; and plumbum corneum and a white precipitate in the ſolutions of lead and mercury. On digeſtion with ſpirit of wine, and then mixing with vitriolic acid, there ariſes a fine acid ſmell; but mixed with fixed alkali, a volatile alkaline ſmell. The gelatinous reſidue from *ſour whey*, in which the acid ſugar of milk has cryſtallized, is according to the ſame author ſouriſh, and likewiſe ſomewhat alkaline to the taſte; it colours the ſyrup of violets and tincture of litmus red, effervesces with common alkalis, colours the blue ſolution of Brunſwick green immediately of an emerald green; decompoſes liver of ſulphur with the common diſagreeable ſmell;

communicates to alcohol digefted with it a yellow colour, and after the evaporation of the alcohol, there remains a brown, pituitous, faline, four tafting fubftance, which effervefces with fixed alkalis, emitting a volatile alkaline fmell, and with the vitriolic acid, an acid fmell. What the alcohol will not diffolve does not effervefce with alkalis, gives no acid fmell with the vitriolic acid, and depofits after folution in water a light yellowifh earth.

Clarified fweet fugar of milk (faccharum lactis puriffimum) which is cryftallized from fweet whey, according to Lichtenftein, is of a milk white colour, confifts of fmall cryftals which are femitranfparent, forming regular parallelopiped prifms, terminated by a regular pyramid parallelogramically rectangular, which at the temperature of 10° or 11° of Reaumur has a fpecific gravity of 1.543.

Water at the fame degree diffolves about the 7th of it's weight.

It is infoluble in rectified fpirit of wine.

It's flavour is rather fweetifh, it has no fmell.

It does not change the colour of turnfole, or fyrup of violets, or the folution of Brunfwick green; it does not render turbid the folution of corrofive fublimate, nor decompofe the calcareous hepar of fulphur. When pulverifed with potafh, lime, or minium, it gives out no ammoniacal odour, nor does the vitriolic acid difengage from it any vapour of the muriatic acid.

It does not decompofe the folutions of filver, lead, or mercury.

It is completely foluble in the nitrous acid; after evaporation, a fermenting mafs is found, which, on being dried and burnt, fhows the fame properties as the pure fugar of milk.

Expofed to a gentle fire in an earthen veffel, there arifes an odour of burnt fugar, it fwells confiderably, and

becomes a black thick mafs, which at firft hardens in the air, but afterwards becomes foft, and when applied to the tongue taftes fweetifh like the fugar of milk itfelf, and leaves a moderately bitter favour in the mouth. In a ftronger heat, it burns to a black fpungy coal, which exhales an odour of burnt tartar.

The fugar from four whey (faccharum lactis acefcens) is the fugar of milk mixed with galactic acid. It is of a yellowifh colour, in fmall cryftals; it's favour agreeably acid, and it's aroma fatty and acidulous.

It is more readily diffolved in water than that from fweet whey.

It effervefces with alkaline and earthy fubftances, by which it lofes it's acidity.

It reddens the fyrup of violets, and the infufion of litmus, and deftroys the blue fhade of the Brunfwick green.

It colours yellow, rectified alcohol, and this as it evaporates takes away all it's acidity; water itfelf extracted from it feveral times does the fame. It precipitates the hepar of fulphur, with a ftrong hepatic aroma.

The fire acts upon it as on pure fugar of milk.

Lichtenftein likewife defcribes a fugar of milk united with oily particles, and it is this which fhoots during the firft cryftallization. It appears of a yellow colour, and becomes rancid in time; when, however, deprived of the oily parts, it is real pure fugar of milk. He likewife mentions another fugar united with an oil and common falt, and which is of the laft cryftallization. It is of a yellow colour, faline favour, gives a muriatic acid odour on adding the vitriolic acid to it, precipitates filver, lead, and mercury white from their folutions in nitrous acid, and in time becomes rancid. He mentions a third fugar united with oil, common falt, and fal ammoniac, which, befides the foregoing properties, poffeffes that of feeling

conſtantly pituitous and moiſt, and affords a volatile alkaline ſmell, on being rubbed with fixed alkalis; and laſtly, another ſugar which beſides being united with oil, common ſalt, and ammoniac, is found tainted with a mucus or a caſeous part, which is not fixed and cryſtallized, but mealy, becoming in time mouldy and rancid, and depoſiting a caſeous matter on it's ſolution in water. This is the moſt imperfect ſort of the ſugar of milk. An acid is likewiſe to be found united with all theſe impure kinds, when they are prepared from ſour whey.

Repeated ſolutions and evaporations of ſugar of milk by a ſtrong heat decompoſe it in part; it ſcarcely preſerves it's ſweetiſh taſte, but has an earthy and diſagreeable ſavour. It very difficultly diſſolves in water; it has the appearance of chalk, and when mixed with an alkali, it depoſits much more earth than pure ſugar of milk.

To purify ſuch impure ſugars, either chalk, calcareous marl, or ſpirit of wine may be employed.

Leonhardi was informed by his friend Geutler, an apothecary in Switzerland, that the peaſants there made uſe of alum, which they bought in large quantities, to coagulate their milk with, and by which they obtained very white ſugar of the firſt cryſtallization; whilſt Prince, an apothecary at Neuchatel, who prepares by unknown means a beautiful ſugar of milk, without the medium of any foreign ſubſtance, entirely rejects this addition. Leonhardi.

When this ſugar of milk is perfectly pure, it is quite white, and nearly taſteleſs.

Rouelle, who has made many experiments on the ſaccharine part of milk, agrees very much with thoſe of Lichtenſtein, reſpecting the ſugar obtained from ſweet whey. In his paper publiſhed in the Journal de Médecine for March 1773, he has given the following account of them. Rouelle.

Whey obtained without cream of tartar affords on

evaporation to the confiftence of a fyrup, and placed in cold, cryftals of the falt or fugar of milk. This mother ley, he informs us, may be evaporated to the third time, and frefh cryftals obtained; but it then contains fome cryftals of digeftive falt of Sylvius. The remaining ley or rather coloured liquor, confifting of the mucous part, is changed fometimes by means of the mucus into a jelly; it alfo contains an extractive matter. This ley, mixed with twice it's quantity of diftilled water, had no effect on the fyrup of violets; nor did a diluted acid effervefce with it.

If concentrated vitriolic acid effervefced fomewhat with the laft cryftallization, or it's ley, there arofe fome muriatic acid vapours, which Rouelle attributed to the falt of Sylvius.

The fugar of milk on diftillation afforded, 1ft. a little phlegm, 2d. an acid, 3d. an oil, 4th. a large coaly matter remained, refembling that from the diftillation of faccharine mucous bodies, as honey, manna, fugar candy, &c. It had no fixed alkaline properties, nor did it effervefce with acids as the coal of tartar does. It afforded fcarcely any afhes on incineration, which were ftill black, and hence contained undecompofed coal. United with water, it changed the fyrup of violets green; and did not, however, effervefce with acids: but Rouelle thinks it contained an uncommonly fmall quantity of fixed alkali; confequently the products of this fugar are the fame as thofe of ftarch and fugar candy, a very few circumftances excepted.

The laft cryftallization, and it's mother ley, afforded by the lixiviation of their coals a little digeftive falt of Sylvius, and a very fmall quantity of fixed alkali, which appeared to Rouelle to proceed from the extractive matter.

The fugar expofed to a ftrong heat in an iron kettle melted in part, and was of the colour of burned fugar.

(caramel): the ſmell was that of burnt honey, manna, or common ſugar. He found two parts of ſugar candy to require one of water for ſolution; and for the ſolution of the ſugar of milk, ſcarcely more than an equal quantity was neceſſary. The ſalt from the incineration of the coal of cows milk afforded him fixed vegetable alkali; the reſt was the ſalt of Sylvius; for being decompoſed by the vitriolic acid, the muriatic acid was ſeparated, and vitriolated tartar obtained. By the nitrous acid he obtained nitre. He found ſix grains and half of alkali in one pint of milk.

From the experiments of Beaume, it appears, that from the third cryſtallization, he obtained cryſtals of common ſalt, and from the mother ley, which produced no more ſugar, he procured a fixed alkali without incineration. He obtained the laſt alſo after the diſtillation of the ſugar. It remained in the retort, and he found this ſugar of milk to have many properties in common with cream of tartar, excepting it's not being ſour. According to Beaume, the whey of the milk of the cow, evaporated to three fourths, affords the ſugar of milk. Beaume.

The ſtrongeſt acids had no effect upon it, at the ſame time he looks upon it to be of a ſaponaceous nature. On expoſure to fire in a retort, he obtained empyreumatic oil, and a fixed alkali remained.

By a ſecond evaporation, he obtained a ſalt reſembling the firſt, which was, however, decompoſed by the mineral acids. The third evaporation of the whey afforded cryſtals of common ſalt.

A fluid remained, incapable of affording more cryſtals, it contained fixed alkali and a little extractive matter, the alkali he obtained without incineration.

Each pint of whey afforded ſeven or eight drachms of theſe ſalts, the origin of which Beaume attributes to the vegetable nouriſhment of the cow.

It appears from the experiments of the two laſt French chemiſts, that in their examination, they attended more to the reſiduum of the evaporation, than to the action of reagents on the ſugar of milk. For a more exact analyſis of it, we are indebted to Scheele and Hermbſtadt, which will clear up any doubts reſpecting it's component parts.

Scheele. Scheele's Memoir on this ſubject was publiſhed in 1780, in Sweden. In this diſſertation, the ingenious chemiſt proves that the ſugar of milk affords the ſame products as any other ſugar; but the moſt remarkable is, that the empyreumatic oil has an aroma approaching that of the benzoic acid, or ſalt of benzoin. By diſtillation with the nitrous acid diluted, he procured real ſaccharine acid as in common ſugar; but from this experiment he was conducted to the diſcovery of the *ſaccholactic acid*; for on treating the ſugar in the ſame way as that for obtaining the ſaccharine acid from common ſugar, he found a quantity of white powder, which troubled the ſolution, and which he got upon the filter on filtrating the ſolution, previous to it's exſiccation to obtain the cryſtals of the ſaccharine acid. The quintal afforded him fifteen pounds and half of ſaccharine acid; and twenty-three pounds and half of the white powder.

Hermbſtadt This memoir of Scheele, it appears, had not reached Hermbſtadt, when the latter publiſhed, in 1782, his examination of this ſalt and it's acid. He did not uſe the fuming nitrous acid, but preferred the double aqua fortis, ſimply rectified on the nitre, and from which he had ſeparated the more aqueous particles that firſt ariſe. Having extracted it, he found in the retort when cooled a depoſit of a conſiderable quantity of earthy matter, and the ſurface covered with a pellicle of the ſame nature; beſides this, he obtained real ſaccharine acid. With four parts of the ſugar of milk, and twenty-ſix of nitrous acid of 1,320 ſpecific gravity, he obtained out of the

quintal only fourteen and one ſixteenth of the acid of ſugar, and forty-three and three fourths of the above mentioned white powder. It may be remarked, that the aqueous ſolution of the ſugar of milk mixes with vitriolic acid as well as mild vegetable alkalis, without affording any depoſit. On diſtillation, he obtained from two ounces of the ſugar of milk ſome very thick white vapours, ſix drachms of a clear yellow, ſtrong, and empyreumatic acid fluid; a few drops of a dark red oil, and ſix drachms of coal; which, on expoſure to a red heat, loſt two ſcruples; and from which ſolution in mineral acids he precipitated with mild vegetable alkali a little calcareous earth.

From the experiments, therefore, of theſe two chemiſts, it appears, that the ſugar of milk well prepared and rectified contains no diſengaged acid or alkali, or mineral neutral ſalt; that it's eſſential conſtituent parts are, 1ſt. a real ſugar like that of the cane, *i. e.* the radical of the ſaccharine acid united to the ſyrupous acid which exiſts perfectly formed; 2d. another ſubſtance of an earthy appearance, and which modifies the exterior characters of the ordinary ſugar.

EXAMINATION OF THE DIFFERENT KINDS OF MILK.

The different kinds of milk that have undergone the inveſtigation of ſeveral of the beſt chemiſts of the preſent time, and upon which ſome very curious and inſtructive obſervations have been made, are ſix in number, viz. the milk of the cow, the human milk, thoſe of the aſs, the goat, the ſheep, and the mare. But although much has been done in order to gain a complete knowledge of their component parts, and of the cauſes that conſtitute their differences; yet there are many circumſtances attending

Six different ſpecies of milk examined.

each ſpecies, which future experiment and obſervation muſt unfold.

Milk of the cow.

Milk of the cow. Since this is the moſt univerſal of any, not only when uſed crude as an aliment, but for a variety of culinary purpoſes, it is not extraordinary that it ſhould have been oftener the ſubject of analyſis; and we have, perhaps, a more exact account of it's nature, properties, and contents, than thoſe of all the others put together. It has been more particularly examined of late by the French chemiſts, from whoſe labours this, as well as the other parts of the ſame ſubject, will be for the moſt part extracted.

Colour, ſmell, and taſte.

The milk of the cow, when firſt drawn, is a white opake fluid, it has a peculiar pleaſant ſmell, is of a ſweetiſh, ſomewhat fattiſh taſte; but theſe properties depend upon a variety of circumſtances, ſuch as the peculiar temperament, food of the animal, &c. Thus immediately after calving, it partakes more of the animal nature, and it receives a diſagreeable and peculiar flavour from various vegetables. We are informed that all plants of the garlic kind, many of the umbelliferous, the horſe mint, cabbages, turnips, autumnal leaves, give it their peculiar flavour. According to Anderſon, it is not uncommon to find the milk of farrow cows ſenſibly ſaline to the taſte, particularly that which is firſt drawn; and that, at laſt, it becomes perfectly ſweet, the ſaltneſs gradually decreaſing from the beginning, and not to be obſerved when about one half was drawn off; and perhaps the ſame circumſtance may be found to take place in milk flavoured by vegetables. Cows that feed on the leaves of maize give an extremely mild and ſaccharine milk; and fed on the potatoe plant, it is inſipid. Likewiſe, the Alderney breed, and the Alpine cows afford a very rich milk both in colour and conſiſtence, whilſt the northern cows give an aqueous and bluiſh milk: the milk of Sardinia is ſo

rich as to afford one half of cream, whilſt that of Catalonia yields very little. In ſummer milk is more or leſs yellow, and in winter white. With reſpect to it's colour, we are informed by Teſſier, of the French National Inſtitute, that he has obſerved milk newly drawn from the cow, and of a beautiful white colour, to become blue in the courſe of two or three days; this was attributed to ſome plants of the nature of woad or indigo, on which cows will ſometimes feed; and Dr. Garden found, that after cows had eaten the ſame plant in an indigo field, the cream of their milk was of a moſt beautiful blue colour. Boiling, although it in ſome meaſure diſſipates the diſagreeable taſte of plants, had no effect on the colour. Cows that feed on the madder plant, give a milk that appears ſtreaked with blood; and after eating the fruit of the cactus opuntia, milk of a reddiſh colour. Gugenmus gave the madder plant formed into hay to his cows, which ate it readily; their milk was ſomewhat reddiſh, and the butter and cheeſe acquired by theſe means, in winter, an agreeable colour.

The milk of the cow, in it's ordinary ſtate, boils at a degree above that of boiling water.

Fixed air has no effect upon it, neither has ſedative ſalt. Effects of reagents upon it.

The vitriolic acid coagulates it into thick lumps, which are ſcarcely afterward diſſolved by potaſh; the other acids act in a ſimilar manner, ſuch as the nitrous, muriatic, phoſphoric, and the coagula are rediſſolved by an alkali.

Vinegar, whether concentrated or not, coagulates it, and the lumps are again diſſolved by alkalis, and become of a roſe colour.

The oxalic acid, according to Stipriaan, only coagulates it when ſtrewed in the form of a powder.

The carbonat of potaſh converts it into a jelly, and if heat be employed, it changes it's colour (or rather the

colour of the whey) to a yellow red, and at laſt a brown. Cauſtic alkali diſſolves it with a yellowiſh colour.

Ammonia thins it, and on boiling heightens it's colour.

Lime water thickens it a little.

Neutral ſalts make it thinner, previous to their thickening it.

According to Stipriaan, highly rectified ſpirit of wine does not coagulate it.

Infuſion of the dried ſtomach of a calf coagulated it.

The electric fluid thickened it ſomewhat.

On ſubjecting it to the vinous fermentation, Stipriaan obtained from it by diſtillation a hot ſpirit.

When the milk is coagulated by artificial means, a mild agreeable ſeroſity is produced of a lemon colour, which is the whey or ſerum.

It's ſpecific gravity to that of pure water was in ſummer as 1028 to 1000.

Diſtillation. We are informed by Parmentier, that on diſtilling the milk of cows fed on different food, he obtained eight ounces of a clear and colourleſs fluid from eight pounds of each milk, but the odour and ſavour were ſimilar to the food of the animal, that lived for nearly one month in a temperature of 16 to 18° of Reaumur. Theſe fluids began to prove turbid and viſcous, and their odour was a little fetid; that obtained from the milk of the cow fed on cabbage underwent a more ſudden and ſenſible alteration than the others, and was ſometimes the firſt to become putrid. Theſe liquors, arrived at the viſcous and opake ſtate, became perfectly tranſparent again at a heat of 28°, whilſt ſome ſlight white filaments were formed, (and this is the caſe with liquors obtained by the ſame means from fleſh, white of egg, and other ani-

mal ſubſtances; all the liquors, which are at firſt very limpid, become turbid at the end of a certain time, loſe their odour, and acquire another which is in general very diſagreeable). On filtration, they become perfectly clear, without ſavour or odour, and on evaporation to dryneſs, little or nothing was left to collect. The reſiduum was thick, greaſy to the touch, of a yellowiſh white, mild, and even ſweet ſavour, and to it Hoffmann gave the name of *Franchipan.* By diluting this in boiling water, a milky liquor is obtained, known in France by the name of Hoffmann's whey. On diſtillation, an aqueous fluid, a very fluid yellow oil, an acid, volatile alkali, a thick black empyreumatic oil, and an inflammable gas are obtained. The carbonated matter, in the retort, is difficult to incinerate. The aſhes change the blue of violets green; when ſulphuric acid is poured on them, vapours of muriatic acid ariſe. Franchipan.

It appears that, on changing the food, although for the better, the quantity of milk becomes very evidently diminiſhed, and it's increaſe is only perceptible after having been accuſtomed to the new regimen for ſeveral days. The aroma appears to form a conſtituent part of the milk. To this, it may be added, that the odour of the plants, diſtinguiſhed in the volatile parts of the milk, are not perceived in the fixed parts. Change of food leſſens the quantity of milk.

Milk taken from the cow immediately after calving is called *beaſtings*, (coloſtrum primum;) it is of a yellowiſh colour; ſometimes mixed with ſtreaks of blood; it is thick and clammy; it's taſte is like other milk, but ſomewhat mucous. Beaſtings.

It's ſpecific gravity to that of water is 1072 to 1000.

On the fire it ſoon coagulates and becomes of a whiter colour.

Milk of the ſecond drawing is not ſo yellow, thick,

or heavy; it's fpecific gravity was found by Stipriaan to be to water as 1052 to 1000. This is more difficult to coagulate, and ftirring prevents it's coagulation.

Properties of it.

Beaftings is coagulated by all the acids; the vitriolic makes it whiter and very thick; the muriatic and nitrous likewife thicken it, efpecially the former. Vinegar only coagulates it in it's concentrated ftate.

Alkalis thicken it, and give it different colours.

The neutral falts render it more thin.

It is coagulated by alcohol.

Rennet changes the firft drawn milk into a jelly, and coagulates the fecond.

Sixteen hundred parts of the firft afforded 187 of cream, 48 of butter, and 300 of cheefe; and the fame quantity of the fecond gave 64 of cream, and 202 of cheefe.

Expofed to the air in fummer, they both become highly putrid in fix or eight days, with the odour of putrid flefh.

More animalized than ordinary milk.

This milk, efpecially the firft, is more animalized than the ordinary milk, and it's liquid part, or whey, agrees very much with the ferum of the blood; it, however, contains very little of this part, on the contrary, a great deal of cream and butter. Independent of the cafeous part, it is very heavy, fcarcely ever becomes four, but undergoes the putrid fermentation proportionably quicker. Stipriaan looks upon beaftings to be milk united with a quantity of ferum of the blood.

Cream.

Cream of the cow. This, on ftanding, becomes thicker and of a deep yellow colour; it lofes it's pleafant fmell for one that is difagreeable; and, according to Parmentier, it became covered over with a green effervefcence in about the fpace of three weeks, whilft the under part had a cafeous favour. It afforded, on diftillation, the fame products as thofe extracted from fat bodies; at firft

a yellowifh oil, of a ftrong and penetrating odour, with fome drops of a liquor flightly acid; afterward volatile alkali; then a charcoal of difficult incineration, but no fixed alkalis were found in it.

We are informed by Dr. Anderfon, that the quantity of cream, collected from the milk of the cow, is different according to the time of it's being drawn, and that a fmall quantity of milk which comes the laft contains about fixteen parts more cream than the fame quantity drawn the firft, at the fame milking; that the cream is much richer, it's colour of a deep orange, whilft that of the other is white. He informs us, that the cream in the firft cafe was a thin tough film, thinner and perhaps whiter than common writing paper, whilft in the laft drawn cup it was of a thick butyraceous confiftence, and of a glowing richnefs of colour, as he expreffes it, which no other cream is found to poffefs. From thefe experiments, "it appears," fays Dr. Anderfon, "that a perfon, who by bad milking of his cow "lofes but half a pint of his milk, lofes in fact about "as much cream as would be afforded by fix or eight "pints at the beginning; and lofes, befides, that part "of the cream which alone can give richnefs and high "flavour to his butter."

Anderfon's obfervations.

If milk be put into a difh and allowed to ftand till the cream arifes to the furface, that portion of cream which arifes firft is richer in quality and greater in quantity than that which rifes in a fecond equal fpace of time; and that which rifes in the fecond interval of time is greater in quantity and richer in quality than in the third equal fpace of time, and fo on. The cream that rifes decreafing in quantity and declining in quality as long as any rifes to the furface.

Dr. Anderfon found, that thick milk always throws up a fmaller proportion of cream it contains to the fur-

face than thinner milk, but the cream is of much richer quality. If water be added to this rich milk, it is found to afford a much greater quantity of cream than it otherwife would have done, but it's quality is debafed. Neither does milk which has been previoufly agitated by carriage afford fo rich a cream, nor in fuch quantity as when it is left to repofe after having been drawn. In this cafe, it is fuppofed, that the lofs of cream will be nearly in proportion to the time elapfed, and the agitation it has fuffered fince the time of being drawn.

With refpect to the feparation of cream from the milk, it appears, that it takes place with the greateft regularity in a temperature of from 53° to 55° of Fahrenheit, which temperature it is neceffary thofe who are engaged in the dairy fhould be acquainted with; for when the heat exceeds 63 this operation becomes very difficult, for the milk is apt to become four and to coagulate fuddenly without permitting the feparation of the cream; if, on the other hand, the milk is kept in too cool a temperature, as under 40°, the cream feparates from it with great difficulty and very flowly, and acquires a bitter and difagreeable tafte.

Milk, in the autumn, is much richer and more coagulable, and gives more cream than in the fpring. It likewife gives it's cream fooner in fummer than in winter. This arifes from the heat which, by giving more fluidity to it's particles, permits them to act according to their fpecific gravity. If, however, this heat be too ftrong or fudden, an acid is produced which coagulates the cafeous part before the cream has had time to feparate. This is the cafe in ftormy weather.

Fourcroy fufpects, that the electric fluid is the principal caufe of this effect; for a good conductor paffing in the middle of a dairy prevents, or at leaft very much retards this coagulation during ftormy weather. Cow's

milk requires twice the time in winter to give it's cream to what it does in fummer. According to Fourcroy, four or five days are fufficient in fummer, and eight or ten in winter, before all the particles of cream can arife; it muft likewife be kept at eight or ten of Reaumur; it will not cream at all at zero, and it freezes a few degrees below it.

The butter of the milk of the cow is in general of a yellow colour; but fometimes it is as white as fat or lard, and is of an inferior quality. The colour, however, depends on the ferum, the phyfical ftate of the animal, and other circumftances. If the cream be got from milk, expofed to too low a temperature, the butter when extracted will be pale, very fmall in quantity, of little tafte, very hard and brittle, and of no value. Butter, likewife, extracted from new cream, has a more agreeable favour than when extracted from old; for to make butter of the beft quality, it will not only be neceffary to feparate the firft drawn milk from the reft, but likewife to take only the firft cream that is feparated from the beft milk, as it is only the firft rifing cream, that is of the beft quality. Thus the richnefs of the highland butter is attributed, by Dr. Anderfon, to the practice of giving the firft drawn milk to the calves, and keeping the reft for the dairy; and the quality and richnefs of the butter will be improved in proportion to the fmallnefs of the quantity of the laft drawn milk. Another circumftance in the feparation of butter from cream is, that it does not take place till after the laft has attained a certain degree of acidity; if, therefore, it be agitated before that acidity has begun, no butter can be obtained; and, according to Anderfon, the agitation muft be continued until that fournefs be produced, after which the butter begins to form; hence, the cream ought to remain in the veffel appropriated for keeping it, until it has acquired that proper degree of acidity by which butter is eafily Butter.

extracted, by a very moderate degree of agitation; and by this process only can very fine butter be obtained. In summer, while the temperature is warm, if the agitation be continued till the acidity is produced, the process will be long and tedious, and the butter is generally of a soft consistence, and gluey to the touch; whilst, if the same be attempted during the cold in winter, butter can scarcely in any way be obtained except by the application of a great heat, which sometimes assists in producing a very inferior sort, white, hard, and brittle, resembling that before mentioned; when the milk has been exposed to too low a temperature, it has very little taste, and is unfit for culinary purposes. Cream, therefore, which has been kept three or four days in summer, is in excellent condition for producing butter; and Anderson is of opinion, that from three to seven days will be found in general to be the most proper time for keeping cream before it is churned.

Robinson's observations.

According to Mr. George Robinson, butter from cream is much richer than that from milk, but is less in quantity, and does not keep so long sweet; a good cow will produce from seven to ten pounds of butter every week.

With respect to the yellow colour of butter, it is pretended, by some people, that it is owing to the aliments; but it is well known that cows, when feeding on the same food and in the same pastures, sometimes give yellow, and at other times white butter; hence it appears, that it is in some measure to be attributed to the constitution of the animal. At the same time, it cannot be denied, but that the aliments may have some share in it's coloration. The contact of the air has likewise an effect in colouring butter, for sometimes that which is quite white acquires a yellow colour a certain time after it's preparation; and butter, on being cut, will some-

times be found to be much lefs coloured internally than externally.

According to Fourcroy, it is neceffary to wait fome time after the cream is formed, before the butter is extracted from it. It appears to him, that the cream abforbs a portion of oxygen from the air, which thickens it, and diminifhes the attraction of the butyraceous particles for thofe with which it was united in the liquid cream; fuch are principally the cafeous particles and thofe of the gelatinous mucilage, a proportion of which is feparated from the cream by the mechanical operation of churning. It appears, that the air very much facilitates the feparation of the cream from the milk, for when milk is placed in vacuo it does not give up it's cream fo readily, nor is the cream fo thick and abundant as when expofed to the air at the fame temperature. It appears that cream, taken from milk of twenty-four hours ftanding, requires at leaft four times longer to give butter than that of eight days, and four times more motion; for it is neceffary that it take in a few hours from the atmofphere in the one cafe, what it had in the other imbibed in feven days, for which purpofe the points of contact muft be multiplied and renewed in proportion, which is brought about by churning. Thefe facts appear to Fourcroy to prove, that the butter is not wholly formed in milk; that it is there in a ftate of oil, which muft abforb a certain quantity of oxygen before it can become concrete. Fourcroy.

Parmentier is not of the fame opinion. "Whatever doubts," fays he, "may be formed of the preexiftence of butter in cream, it muft be allowed that cream has the general properties of oily matters. It is fpecifically lighter than milk; is unctuous to the touch; it fpots cloth like fat bodies; it grows rancid, and at length contracts a ftrong tafte, which gives reafon to fuppofe Parmentier.

that butter is contained in cream, but under a ſemi-combination, which agitation alone can deſtroy." He has endeavoured to ſupport this opinion by experiment. He endeavoured to deprive cream of it's ſerous part, which conſtitutes it's fluidity, without altering it's properties; for which purpoſe he procured a certain quantity upon ſeveral leaves of grey paper, which, after being impregnated with the ſerous part, left the cream as ſolid as butter. It was then collected and diluted with a certain quantity of diſtilled water, ſufficient to reſtore it to it's former fluidity; and on agitating the fluid, the butter ſeparated as uſual; the ſeroſity was only extremely inſipid; which, according to Parmentier, was a proof that the ſaline matter diſſolved in the ſerum does not ſerve as an intermediate body to unite the butter with the cream. Some drops of vinegar added to freſh cream, in order to attack the caſeous part, had no effect in promoting the extraction of the butter, but retarded it, and the laſt retained a little of the caſeous part into the bargain. This experiment likewiſe proves, according to this chemiſt, that the promptitude with which the butter ſeparates from ſour cream depends leſs on an acid developed in this fluid, than on the ſpecies of fermentation which has produced this acid.

Beſt ſorts of Engliſh butter.

They who are deſirous of knowing the method of making good butter ſhould attend to the methods which are employed in the beſt dairies; ſuch is the *Weſt country* method, as Dr. Anderſon has called it. They firſt depoſit their milk in earthen pans, and let them remain twelve hours in ſummer and twenty-four in winter; they are then removed to ſtoves, heated for that purpoſe with hot embers; here they remain till bubbles ariſe and the cream changes it's colour, this is called *ſcalded* cream. It is then removed with care to the dairy, where it remains twelve hours longer, when it is ſkimmed, and the

cream is churned. The Cambridgeſhire ſalt butter is made nearly in the ſame manner, and is in the higheſt eſteem. This, when deprived of it's ſalt by waſhing, is ſold at a high price in London as freſh butter. Nearly the ſame method is purſued in Suffolk and Yorkſhire, and the butter is not much inferior to that of Cambridge, being often ſold in London for that butter. The food is often found to affect the butter, as wild garlick, charlock, or May weed, turnips and rape. A great part of the Epping butter, according to Dr. Anderſon, is made from the cows that feed, during the ſummer months, in the foreſt, where the leaves and ſhrubby plants greatly contribute to it's flavour. The mountains of Wales, the highlands of Scotland, and the moors, commons and heaths of England, produce excellent butter where it is properly managed; and though not equal in quantity to that produced from rich meadow land, yet is ſuperior in flavour and quality.

To this ſhort digreſſion on the making of butter in the dairy, may be added this method of preſerving it: To preſerve butter more effectually than ſalt from any taint of rancidity, the following preſcription has been uſed: One part of ſugar, one of nitre, and two parts of the beſt Spaniſh ſalt, are to be finely pulverized together, and kept for uſe; one ounce of this is to be mixed thoroughly with ſixteen ounces of the butter, as ſoon as it is freed from the buttermilk; it is then to be put into a cloſe and perfectly clean dry veſſel, from which the air is to be carefully excluded, and it will remain good for many years. Preſervation of butter.

Butter muſt be divided into ſmall portions and well waſhed, until the water ceaſes to be milky, otherwiſe ſome portions of the cream will remain, by which it ſoon loſes it's delicate flavour for a ſtrong diſagreeable ſharp taſte, vulgarly called *rancidity*. Butter appears to Rancidity.

be more fufceptible of this fpontaneous change than other oily matters. This may be retarded by keeping it in a cool place, or mixing falt with it. Parmentier wafhed, more or lefs perfectly, equal quantities of butter of his own making from excellent cream, and when placed in the fame temperature they became fooner or later rancid, according as they were more or lefs well wafhed. To prove, in a ftill more evident manner, the prefence of cream or milk in butter, and it's action on this oily body, two ounces of frefh butter were melted by a gentle heat in a fmall pot, and an equal quantity of rancid butter in another veffel; after cooling, a fmall portion refembling cream was found at the bottom of the veffel; that of the firft had a mild favour, whilft that of the fecond was very fharp. This effect became infinitely more fenfible on increafing the fluidity of the butter, by adding equal parts of oil of fweet almonds. Suppofing thefe experiments not fufficient to prove the influence of the cafeous matter on the rancidity of butter, it is fufficient to pay attention to the daily practice of dairymaids, who, on melting their butter, find the cafeous matter precipitated to the bottom and torrified; likewife, by kneading rancid butter with water, it will foften it's ftrong tafte. With refpect to rancidity proceeding from an acid, as fome chemifts have imagined, it is proved by experiment, that neither rancid butter, nor old cheefe, either coagulates milk or reddens the blues of vegetables.

Pure butter, expofed to a gentle heat, melted and well wafhed, does not become rancid fo foon as other butter, but it is not fo agreeable to the tafte; and it appears probable to Fourcroy, that it is on this account a certain quantity of cheefe is always left in it, which renders it opake, and which may be feparated by gentle fufion; the butter, likewife, is more marrowy after fufion. Fourcroy put fome frefh butter of the market into a tube of

one inch diameter, ſtopped it at one end, and plunged it into hot water; at the temperature of 28° it ſeparated into three parts; the cheeſe was at the top, apparently drawn there by ſome air blebs which appeared to adhere to it more than to the other matters; the pure butter was in the middle, and water in the inferior part.

Butter, melted by this gentle heat, has not the ſame properties as before; it's colour, ſavour, and texture are changed; it is become ſemitranſparent, and granulated; it's ſavour is inſipid and ſimilar to that of fat: theſe changes which butter undergoes in melting, are cauſed by the ſeparation of the caſeous part and the mucilage. *Vide* oils, article butter.

Buttermilk. We are informed by Parmentier, that this fluid reſembles perfectly ſkimmed milk, in all it's phyſical, chemical, and economical properties. When it is acid, as happens in the ſummer months, or when it is taken from old creams, it has a ſavour manifeſtly ſharp, and is leſs white than common milk; it is then clarified with extreme quickneſs, the developed acid coagulating one part of the caſeous matter, and the ſolution the other. Buttermilk is not ſo ſharp as the acid cream from which it is taken, owing to the percuſſion during churning having either deſtroyed the acid or forced it to combine with the caſeous matter; buttermilk, therefore, differs from milk only by being completely deprived of it's butyraceous matter. Butter-milk.

Skimmed milk. Milk, when deprived of it's cream, has neither that dead white colour which it has in winter, and yellow colour in ſummer, nor that unctuous conſiſtence and ſweet ſavour which it has when freſh drawn; and as it's denſity is decreaſed it is boiled by an inferior heat. It is likewiſe capable of diſſolving a greater portion of ſugar, and other ſaline bodies. It is owing to the abſence of the cream in this milk that it is preferred for Skimmed milk.

whey, the clarification being more complete, and it does not ſpoil ſo ſoon. If ſkimmed milk be left in the open air, or even in a bottle, it loſes it's ſweet ſavour, contracts a ſharpneſs, and changes into a ſerous liquor; in the midſt of which floats a coagulum which is eaſily ſeparated by decantation, eſpecially if the veſſel be expoſed to a gentle heat, and is the caſeous part.

If this milk, which has juſt begun to turn ſour, be put into a veſſel and placed in ſome heated water for one night, this caſeous matter will be ſeparated into a thick creamlike ſubſtance and occupy the upper part, which is not much leſs in quantity than one half of the milk; when this is well done, it appears to be as rich and fat as real cream, and is only to be diſtinguiſhed from it by it's ſourneſs; it is eaten with ſugar, and is eſteemed a great delicacy; it however requires practice to make it nicely, and give it a proper creamy conſiſtence; the degree of heat and other minute circumſtances greatly affecting the operation.

Skimmed milk being expoſed to heat on the baln. marin. pellicles ariſe as before-mentioned, article *milk*. In proportion as they are formed, the milk becomes thick, hence, water muſt be added to preſerve it's fluidity; when it ceaſes to give theſe pellicles it is tranſparent and fluid, and no longer to be curdled by acids: in ſhort, it is whey, or the ſerum of the milk. Being left ſix days in a veſſel, theſe pellicles gave an inſupportable odour. On the fire, they bliſter and expoſe an odour of burnt horn, and afford on diſtillation the ſame products, viz. phlegm, light oil, ammonia, and an empyreumatic oil; a charcoal remains of difficult incineration. One of the moſt remarkable properties of theſe pellicles is, to be diſſolved by cauſtic ſoda. The ſolution is of a deep red. This colour Parmentier thinks is due to the carbon, which is firſt ſeparated and then diſſolved by the ſoda.

The caseous matter, being the same as the pellicles just mentioned, possesses their properties; when fresh and moist, it is in part soluble in the alkalis, but when exsiccated they act very little on it. The manner in which fixed alkalis act on fresh curd merits a particular examination. When flakes of cheese are put into liquid and caustic potash or soda, they become transparent, and are dissolved, whilst a great quantity of ammonia is disengaged, as observed both by Fourcroy and Parmentier; the same takes place with the gluten of wheat, and animal substances, as flesh. This ammonia appears to Fourcroy to be formed at the moment of the action of the alkali, for fresh cheese has no character that indicates it's presence; it neither changes blue vegetable colours green, nor gives ammonia at a mild temperature. It appears, therefore, that during the time the fixed alkalis tend to unite with a certain portion of cheese; it's principles immediately change in their attractions; a certain quantity of it's hydrogen and azot combines apart to form ammonia; the water contributes much, for the production of ammonia does not take place in dried cheese. Caseous matter.

That portion of cheese which the alkali holds in solution gives the liquor a brownish yellow colour, which becomes brown on the application of a little strong heat; in the last case a small quantity of carbon is deposited. This matter may be separated from the soda and potash by an acid; but then it no longer possesses the ordinary properties of cheese. It has a black colour, melts in the fire like a thick oil, becomes dry no more, but remains greasy. It appears that the azot and hydrogen are first disengaged to form the ammonia, whilst the hydrogen and oxygen becoming more abundant in the caseous matter, give it it's oily characters, so that it's solution by the alkali forms a sort of soap.

According to Parmentier, if this combination of the

cafeous matter with foda be decompofed by an acid, an hepatic odour is difengaged. He found that the vitriolic acid has very little action on the cafeous matter. The fuming nitrous acid diffolves it at a boiling heat, but diftilled vinegar he found to be the acid which (contrary to Scheele) the moft completely diffolved it.

Scheele has fhown that the acids in coagulating cheefe diffolved a part of it in proportion to the quantity of acid employed. According to Fourcroy, the cafeous part has a ftronger attraction for fome acids than for others, and in general for the vegetable acids, as vinegar, lactic acid, and amongft the mineral acids for the diluted fulphuric. It has likewife a ftrong attraction for the fweet ferum of the milk, fince this liquid by whatever means it has been clarified, always depofits fome of it on paffing to the acetous ftate.

Whey. The favour of this fluid, when frefh, is fweetifh and fomewhat faline, and when filtrated, poffeffes the greateft limpidity. Mixed with the fixed or volatile alkalis a white depofit is formed, which is a portion of the cafeous matter held in folution by an acid. On the addition of an acid, it is expelled.

Whey is ufed in the bleaching of linen. It is left eight or fifteen days in large veffels of this fluid, and taken out perfectly bleached. In this cafe the acid of the whey is decompofed, and the oxygen acts on the colouring matter.

Serum, evaporated and placed in a frefh place, affords white cryftals, which are the fugar of milk. Parmentier found no fixed alkali in the mother water, only the muriat of lime was prefent. Hence he concludes with Rouelle, that fixed alkali is not effential to milk, and that when found in it, it is, like all the neutral falts, carried there by the nourifhment or drink of animals.

The beſt cheeſes in England, ſuch as the Stilton, the Cheſhire, and the Glouceſter, are made from the milk of the cow, and their difference appears to depend more on the manner of making them, than on any peculiar properties of the milks. According to Parkinſon, the Stilton is made of the curds from ſour and ſweet milk mixed together, and the whey preſſed lightly out; and the richneſs depends in ſome meaſure on the quantity of cream. It is afterward turned often, and not dried too quickly. Cheſhire cheeſe is made of new milk, and it's rich flavour and mellowneſs are owing to an addition of ſweet beef ſuet, or any other which is poured into and mixed with the curd, with a ſufficient quantity of ſalt to keep it from rancidity. It is found that the hotter any kind of cheeſe is put together, the ſounder it will be; and the colder you put it together, the richer it is, and the ſooner it will decay. Another ſort made of this milk, and of great celebrity, is the Cottenham, or Eddiſh cheeſe; it is thin and ſoft. English cheeſes.

HUMAN MILK.

This milk is of a ſlight bluiſh colour, it's ſavour mild and ſaccharine, and of a ſweetiſh odour.

It's ſpecific gravity is to diſtilled water as 1029 to 1000.

Expoſed to the air in a freſh place, it's ſurface becomes covered over with a thick very white matter analogous to cream. From this cream Parmentier could procure no butter by agitating it for ſeveral hours; it was then left in a temperate place, when on the ſecond day a very clear colourleſs liquor was obſerved at the bottom of the veſſel, and on the ſurface was a thickiſh fluid, very white and of a mild and unctuous ſavour, but butter could not be Expoſure to the air.

Distillation. feparated from it. It was then put into a retort and diftilled, which forced over fome phlegm, a ftrong empyreumatic oil, volatile alkali, an acid, and inflammable gas; the liquor, therefore, on which this analyfed matter fwam may be looked upon as a butter milk; it's tranfparency was not changed either by acids or fpirits of wine. By infenfible evaporation it afforded a faline refiduum, found to be fugar of milk, mixed with fome cafeous matter. Human fkimmed milk placed in rather a warm temperature did not coagulate in five days, it became, however, turbid from the evaporation, and fenfibly acid. On letting the evaporation continue, cryftals of fugar of milk were formed, and there remained at laft a thick mother ley, which, evaporated to drynefs, afforded muriat of foda. When heated for pellicles to appear, they arofe fucceffively as in the milk of cows, and the reft was ferum.

Coagulation. All the methods of coagulation ufed in cows milk fucceeded, except vinegar, and the mineral acids very much diluted with water.

It appears that the longer a milk is drawn from the time of lying in, the more cafeous matter it contains, and then it is coagulated by acids; but the coagulation is always vifcous, and never acquires that gelatinous confiftence obferved in the cafeous matter of the cow. The cream of human milk foon after lying in is very fmall in quantity, but it increafes as it recedes from that time; this cream is always of a dead white colour, which in a fhort time becomes of a thick confiftence, without acquiring, however, that unctuous appearance which characterizes the cream of the cow. The obfervations which Parmentier has made on this milk are highly deferving of attention.

(Margin notes: Curd. — Cream.)

It's conftituent parts difficult to afcertain. "Perhaps," fays this chemift, "there is no fpecies of milk the products of which vary fo much as the human,

hence the insufficiency of every comparative analysis with that of other females. At each instant of the day, this fluid changes it's state, and the changes it undergoes are sometimes so marked, as to astonish the most experienced observers. We were at first so much struck with these differences during the same day, that we were apprehensive the milk might have been diluted with water. To avoid this suspicion, we analysed only that which had been drawn in our presence. But the consequences being still the same, we concluded, that it can never be in the power of the chemist to determine the quantities of each of the constituent parts of this fluid in a manner sufficiently positive to obtain a term of comparison, that will not be variable, since it is impossible to find two kinds of this milk perfectly similar."

The cream appears to be in a greater abundance in human milk than in that of the cow, and it differs from it very essentially in it's component parts. In that of the cow the butyraceous particles are as it were mixed with the caseous part of the serum, and agitation alone is sufficient to produce the butter; but in the human cream, the caseous matter is not only simply mixed with the butter, but it is so combined as to appear impossible to separate it. Besides, the human butter is most probably less solid than that of the cow, because the cream which contains it only acquires by percussion a thickish consistence; perhaps it is likewise to the small disposition which the butter has to take a concrete form, that the impossibility of it's separation is owing, and the property it has of remaining combined with the caseous matter from the greater affinity of their particles. "In short," says Parmentier, "to be convinced that the caseous matter and butter exist in human cream, it is sufficient to know that the cream very soon grows rancid, and that the products it gives by distillation in the open fire are precisely the same

Cream compared with that of the cow.

Butter.

as thofe from the cream of a cow treated in the fame manner." The property of the human milk, in not being always fubject to coagulation by acids, appears to depend on the fmall quantity of cafeous matter it contains, and it's extenfion in this fluid; and this explanation is confirmed by Scheele's experiments, which prove that cow's milk, diluted with fix parts of water, lofes the property of coagulation. It alfo appears that the cafeous part adheres very flightly to the ferum; fince by repofe alone, it is found in great part to feparate from it in the form of exceedingly tender molecules adhering to the fides of the veffel. Another character which diftinguifhes this milk from that of the cow, is the faccharine favour; yet the quantity of fugar the human contains is fcarcely fenfibly greater. Perhaps the caufe of the great developement of the faccharine matter in this milk arifes from it's not being as it were mafked by that of a great quantity of cafeous matter.

Stipriaan's experiments.

From the experiments of Stipriaan, the human milk was not coagulated by any of the acids, whether heat was ufed or not; nor was it coagulated by any of the alkalis, mild or cauftic: foda of potafh, however, by the means of heat, gave it a yellow, brown, red, and at laft a black colour, which colours were weakened by the vitriolic acid.

Lime water, when boiled with it, produced a deep yellow colour.

The earths, neutral falts, &c. occafioned no change.

Infufion of oak bark formed a coagulum of a yellow colour.

Alcohol had no effect upon it.

Vitriol of copper, and the folutions of this metal in muriatic acid and vinegar, produced a blue colour; a folution of filver in nitrous acid gave it a dirty rofe colour; and tin in the fame acid a beautiful rofe red.

The rennet of the lamb and calf did not coagulate it.

Sour coagulated milk when added to it produced a coagulum.

The electric fluid had no effect upon it.

The coal after evaporation afforded particles of iron.

The caseous part was coagulated by either letting it become sour and boiling it, or using old sour milk; this cheese was much finer, more tender, and softer than that of other milk; it, however, cannot be collected in a lump. Sixteen hundred parts of this milk afforded 137 of cream, 48 of butter, 43 of cheese, and 117 of sugar; 300 parts of this last gave 85 of lactic acid. Contents.

Human milk becomes difficultly sour, it requires very often a fortnight and longer; sometimes when it has been kept a long time, it is insipid, and remains for months without undergoing the acetous fermentation; from 300 parts of the sugar, Stipriaan obtained 85 of the acid of sugar of milk. He was unable to bring it to the vinous or putrid fermentations. Acetous, vinous, and putrid fermentations.

It is, perhaps, owing to the great difficulty, if not impossibility of procuring this milk in a nearly similar state, which some authors have attributed to the irregularity of the human method of living, that the experiments of chemists differ so much respecting it's coagulation; as there is no other milk which is so readily affected by the difference of nourishment. It is now asserted by Dr. Clarke, that it contains little or no caseous part. He attempted it's coagulation with all the different acids, alcohol, heat of various degrees, infusions of infants stomachs in various proportions, and assisted by different degrees of temperature, without the least success. He confirms in this respect the experiments of Ferris and Young, and states against Dr. Rutty, that if he had previously skimmed the milk, from which, by the means of rennet, he thought he had produced a little curd, he would have been unsuccessful. From his own experiments, which have been nu- Clarke's ideas on coagulation.

merous and of great variety, he concludes that the matter often vomited up by fucking infants, and which has been fuppofed to be coagulated milk, is not the cafeous part, but a foft vifcid matter, which he looks upon to be the cream. He was confirmed in this opinion, by obferving that the human milk always threw up a copious yellow cream for fome days after delivery, and having interrogated the nurfes at the Lying-in Hofpital on this fubject, they informed him that the matter vomited up was yellow only during the *beafting period*, and that it afterward is white.

MILK OF THE ASS.

This milk is of a whitifh colour, and according to Stipriaan, not fo opake as the other kinds. It has a peculiar odour and fomewhat fweetifh tafte, accompanied with a flight faltnefs.

It's fpecific gravity is as 1023 to 1000.

All the acids except the weakeft, as the fluor acid, coagulate it.

Properties. Alkalis produce a very flight coagulation and various colours.

Neutral falts render it fomewhat thinner.

Cream of tartar only coagulates it when warm.

Alcohol, rennet, folutions of lead, zinc, tin, iron, and copper in acids, coagulate it, and likewife produce more or lefs deep colours.

The coal after diftillation afforded particles of iron.

This milk difficultly coagulates fpontaneoufly, and the coagulum is not very confiftent.

The *cream* is of a yellowifh white colour, fweet fapid tafte, and at firft thin, but afterward thickened in confiftence.

The whey is ſweetiſh and of a yellowiſh colour.

The ſaccharine matter poſſeſſes a ſlight ſaline ſavour. Sixteen hundred parts of this milk afford 47 of cream, 53 of cheeſe, and 72 of ſugar of milk; 600 parts of this ſugar gave 155 of acid.

It appears that although all acids and ſpirituous liquors coagulate this milk, it is in a different manner from that of the cow, for the caſeous matter always ſeparates in the form of extremely tenacious particles, which aſſemble at the bottom of the veſſel, whilſt the coagulum of the milk of the cow is in a maſs, and occupies the whole of the fluid from which it is with difficulty detached. Obſervations on it's coagulation.

This milk affords a *cream* that is never thick or abundant; it is with difficulty converted into butter, and this butter when extracted from it is always ſoft, of a white colour, and without any marked ſavour. If care be not taken to ſeparate this butter from the buttermilk as ſoon as it is formed, or if it be kept in a warmiſh place, it liquifies and mixes with the buttermilk, and cannot be ſeparated again without plunging the veſſel into cold water, and then uſing agitation. Cream. Butter.

According to the experiments of Parmentier, this buttermilk well deprived of it's new cream has a very mild agreeable ſavour, and the caſeous matter is ſeparated from it by acids, &c.

The *ſerum*, on evaporation, afforded a very white ſugar, but not in the quantity expected from it's ſweet ſavour; a little calcareous muriat was likewiſe found in the ſerum. Serum.

From the obſervations of Parmentier, it appears that aſſes milk is one of thoſe which contains the leaſt caſeous matter; it adheres ſo little to the ſerum, that repoſe alone without any acidity is often ſufficient to ſeparate it; it then appears in the form of very fine particles. In this, it agrees with the human milk, which is ſuddenly converted into ſerum. In proportion as the caſeous matter

manifests itself, the saccharine savour becomes more evident, which effect cannot be attributed to the evaporation of the fluid, but to the evolution of the sugar.

The cream is never in abundance.

From the want of sufficient consistence in the butter, it cannot be had in a solid state during summer, and in winter it resembles a fluid oil. It's colour is of a dead white, whether in summer or winter, which gives rise to suspect that it contains a small portion of caseous matter, and the facility with which it grows rancid seems to confirm this opinion.

The salts contained in the serum, Parmentier found were not always the same; muriat of lime was the most general, but he has likewise obtained an admixture of muriat of soda. The first was of the cubic form, the other in a state of deliquescence, but the quantity of these two salts are very inconsiderable.

MILK OF THE GOAT.

GOAT's milk is very white, of a peculiar smell, and of a sweetish, somewhat fat savour, which is very different from those already mentioned.

It's specific gravity is greater than that of the others; it is as 1036 to 1000.

With reagents, the changes in this milk are much the same as the last.

Cream. To separate the *cream*, the milk must not be placed in too cool a place; the cream is exceedingly thick, of a mild and agreeable savour, and when exposed to the air keeps a long time without suffering the acetous fermentation. From it's being so very thick, it is easily converted into a sort of cheese, which keeps well, and is very

rich. By agitation, butter is eafily obtained; it is of a white colour, firm and folid in confiftence, and in other refpects refembles other butters. Butter.

The *buttermilk* abounds in cafeous parts; fometimes it contains more than the human and cow's milk. It is mild and agreeable to the tafte, and it's cafeous matter may be feparated by acids, fpirit of wine, &c. Buttermilk.

The quantity of curd is, from what has been faid, very confiderable, and is always in the form of a magma, fo thick as to caufe the feparation of the ferum with great difficulty. From the experiment of Parmentier and Deyeux, it appears that the abundance of cafeous matter in this milk is it's principal character; in this refpect, it is very different from human and afs's milk; it is to this circumftance that it's great denfity is to be attributed, and the prodigious quantity of pellicles it affords on being heated. Another remarkable circumftance is the gelatinous ftate of this cafeous matter on it's feparating from the ferum, being very different from that of human or afs's milk, which never acquires any confiftence, but appears in the form of extremely divided particles. Independent of thefe properties, this cafeous matter of the milk of the goat, confidered as an aliment, unites feveral others of great magnitude. Cheefes are made from it which are extremely rich, marrowy, and melting, and of a very agreeable tafte. Abounds in cafeous matter.

As the cream is very thick, but never fo yellow as that of the cow, the butter which is feparated is always white; this, however, like that of the afs, does not depend on the interpofition or combination of a certain quantity of cafeous matter. It's confiftence and manner of being acted upon by heat prove, that it does not depend on any foreign body for this property; befides, after having been kept a long time, if melted on the fire, it affords no depofit, as is the cafe when butter contains cafeous mat-

ter amongſt it's particles. It is moſt probably to this ſtate of perfection, that this butter has the property of keeping freſh a much longer time than any other.

From Stipriaan's experiments, it appears that 1600 parts of this milk contain 127 of cream, 73 of butter, 146 of cheeſe, and 70 parts of the ſugar of milk; one fourth of which is the lactic acid.

With reſpect to this laſt part, the ſaccharine matter, Parmentier's experiments prove, that in this milk it is not in proportion to the caſeous matter; it contains even leſs than the human and aſs's milk; it is always very white when the ſerum is ſpontaneouſly evaporated; if, however, artificial heat be uſed, the liquor at the term of cryſtallization remains ſirupy, and it's conſiſtence increaſes until it reſembles a jelly. The cryſtals are alſo coloured, which is the reaſon why the ſugar of this milk, which is made for commerce, is of a reddiſh colour. Theſe inconveniencies are avoided by ſpontaneous evaporation.

Parmentier found this ſerum to contain a very ſmall quantity of marine ſalt. It is the only foreign ſalt the preſence of which is ſeen in the mother water remaining after the cryſtallization.

MILK OF THE SHEEP.

Reſembles that of the cow.

In appearance, the milk of the ſheep is very ſimilar to that of the cow, and their phyſical qualities have a great reſemblance.

It's ſpecific gravity is to diſtilled water as 1035 to 1000.

It eaſily undergoes the acetous fermentation in ſummer.

Left to repofe, it is foon covered over with a thick yellowifh cream, pretty large in quantity, of a mild and agreeable favour. This affords a good deal of butter, which never becomes of a very folid confiftence. It's colour is of a pale yellow, and leaves an oily impreffion in the mouth. It eafily becomes rancid, particularly if not well wafhed. The cafeous matter, whether obtained by fpontaneous or artificial means, always, according to Parmentier, preferves it's fat and vifcous ftate, which prevents it's being eafily collected; it's favour is mild and agreeable. The ferum when evaporated afforded a very white fugar. According to Stipriaan, 1600 parts of this milk afford 185 of cream, 93 of butter, 246 of cheefe, and 67 of fugar, which gave one fourth of the lactic acid, and nearly as much from the fluid which remained. All the acids, and even the acid of fluor, coagulate it; fixed air has no effect upon it.

Soda and potafh gave it a dark colour; if cauftic, a red. Ammonia appears to make it thinner, and gives it a yellowifh colour.

The neutral falts have no effect upon it.

It is alfo coagulated by alum, liver of fulphur when warm, and cream of tartar.

Although the difference between this milk and that of the cow is difficult to be afcertained by infpection, Parmentier found by analyfis, that it's characters are fufficiently evident to prevent their being confounded together. This difference foon appears from the quantity of cream it furnifhes; afterward the butter extracted from it prefents to the chemift a ftill more marked difference, both with refpect to it's confiftence and tafte. With refpect to the cafeous matter, the difference is ftill more ftriking, and affords a character which peculiarly belongs to it. It is remarkable for it's fatnefs and abundance.

From the richnefs of the butter, and the vifcofity of the cafeous matter of the milk of the fheep, it forms a part of certain kinds of cheefe by mixing it with the milk of the goat; as in thofe of Roquefort, which, without this admixture, would be too dry and lefs delicate, the milk of the goat giving it whitenefs. This is one of the moft famous cheefes that France affords. As to the reft, the fuperiority which the milk of the fheep is known to poffefs in giving to cheefe it's richnefs, is recorded by this ancient proverb, *beurre de vache, caille de chevre, et fromage de brebis*. The muriat of foda found in this milk by the French chemifts, has given rife to a fufpicion of it's proceeding from the falt which is given to them.

Roquefort cheefe.

From the celebrity of the Roquefort cheefe above mentioned, it will not be departing from confidering it in a chemical point of view to give fome account of it's formation, and other properties.

Obfervations of Chaptal upon it.

We are informed by Chaptal, that the goats and the fheep, of the milk of which this cheefe is formed, feed upon the Larzac, a large plain of ten leagues in diameter, very fertile and rich: he affirms that it's quality feems to depend more particularly on the firft operations in making. It often happens that cheefe brought from different farms to Roquefort are of a very different nature, although from herds fed in the fame manner. It is alfo frequently obferved that cheefe from the fame farm, made by the fame perfons, and with equal care, are of different qualities. Chaptal is of opinion that thefe varieties of quality originate from the firft operations it undergoes in it's manufactory. He agrees in opinion with Huzard, in attributing the caufes of the bad quality of cheefe to the rennet. He thinks that it's ever variable nature; the fojourning of the milk in the ftomach of the calf; the variable quality of the curd; the more or lefs perfect mixture of the gaftric juice with the food; the gaftric juice

itſelf; and even the age, conſtitution, and temperament of the animal; all of them have more or leſs influence upon it. To obviate theſe faults, the rennet ſhould be conſtant and invariable in it's nature and virtue, this muſt be looked for amongſt the acids. The manipulation has alſo great effect upon it. All the whey ſhould be entirely preſſed out, otherwiſe it becomes ſour in a few days and ſpoils the cheeſe. The cheeſe when made ſhould be dried in a freſh and dry air, and the month of May is the beſt ſeaſon for this purpoſe. Delmas has found ſuch cheeſe very ſuperior to others; the fermentation having been thus prevented, and perfect dryneſs obtained. They are preſerved in cellars of proper coldneſs, and with conſtant air.

The character of this cheeſe is mildneſs, whiteneſs, firmneſs, an agreeable taſte, and colour marbled with blue. It, however, ſoon changes it's quality from change of temperature and tranſportation; and ſo nice is it's point of excellence, that it is agreed upon by connoiſſeurs, that it is only at Roquefort an exact idea can be formed of it. The firſt degrees of fermentation when in curd make it inſenſibly loſe the inſipid taſte it has in that ſtate, and at laſt it contracts a ſharp diſagreeable ſavour; it is therefore between the extremes that the fermentation muſt be ſtopped. It is alſo neceſſary to attend to the changes after having been ſalted and placed in the cellars. It is firſt covered with a white down, which afterward becomes blue and then red. Theſe colours ariſe from the attraction of oxygen, which by producing a different denſity, or otherwiſe changing the poſition of the particles, renders them proper to refract ſuch and ſuch rays, according to the refractive power of each. As the blue ray is the weakeſt, it is the firſt reflected when the oxygen gas is fixed in a body, producing the putrid fermentation. The red which ſucceeds the blue in this cheeſe is likewiſe a

natural confequence of the fame principle; and in effect, it is proved according to Chaptal, that the red ray is that which has the ftrongeft refrangibility, it is therefore that which is reflected when the concentration and combination of the oxygen gas is the ftrongeft; this is feen in the calcination of moft of the metals, and in the blood; but the nature of the principles with which the oxygen gas combines, and it's greater or lefs affinity with the different particles, modify the combinations and vary the refults. It is from this red colour that they are able to judge of the perfection of the cheefe.

MILK OF THE MARE.

It's properties.

This milk, like the reft, is white and opake; it's fmell is peculiar to the animal, which it retains in all it's parts, and it has a fweet and as it were an aqueous favour.

It's fpecific gravity to diftilled water is as 1045 to 1000.

The vitriolic, muriatic, and nitrous acids, coagulate it into thick lumps.

The phofphoric acid deprives it both of colour and opacity, fo that it appears like water.

Acid of fluor has no effect upon it in the cold, but when warm flightly coagulates it; a fimilar effect is produced by the acid of fugar.

The alkalis render it more thin, and change it's colour.

Lime water has no effect in the cold, but precipitates the cafeous part when warm.

Neutral falts render it thinner and clearer.

Highly rectified fpirit of wine renders it equally curdy.

According to Stipriaan, an infuſion of rennet has no effect upon it.

This milk is ſomewhat remarkable for it's fluidity; it, however, is leſs ſo than the human, and that of the aſs; but it is more inſipid as to it's ſavour. It's phyſical properties have great reſemblance to other milks. Parmentier, however, obſerved that it eaſily boils, and is not difficult to coagulate. It's diſtilled water is nearly inodorous, and it gives a frangipane leſs unctuous and abundant than that of the cow. This milk ſcarcely feels the heat of the baln. mar. before it is covered with pellicles leſs than thoſe of the ſheep; and thoſe which appear the firſt are the moſt unctuous, which is to be aſcribed to the ſmall quantity of cream it contains.

The ſerum, when the pellicles are taken away, is always very clear and colourleſs. With reſpect to the cream, it is pretty clear and of a yellowiſh colour; it ariſes very ſoon after the milk is drawn from the animal. It affords no butter though agitated a long time; it increaſes, however, in conſiſtence, but affords no buttermilk, at leaſt Parmentier was not able to procure any. The ſkimmed milk has the properties of that of the cow and goat; it is, however, obſerved by the above chemiſt, that diſtilled vinegar and cream of tartar operated more difficultly the ſeparation of the caſeous matter, and when it appears ſome time after the mixture, it is in a form analogous to that of human milk treated in the ſame way. The ſerum by ſpontaneous evaporation was covered with a white cryſtallized ſalt in ſmall needles, ſometimes grouped, and ſometimes iſolated, and it likewiſe afforded a ſaline concretion; the firſt was found to be ſulphat of lime; the other, ſugar of milk; and after two other cryſtallizations, the liquor remaining refuſed to cryſtallize; it contained muriat of lime. Sixteen hundred parts of this milk, according to Stipriaan, afforded 13 only of

cream, 26 of cheefe, and 140 of fugar of milk; 100 parts of this laft gave 30 of the lactic acid.

The experiments of Parmentier and Deyeux on this milk, were made upon fome which had been taken from the animals two months after foaling; they found, that on fimple infpection, it was eafy to judge of it's ferous ftate, and they foon had a proof of it by the fmall quantity of cafeous matter it contained. They found, that diftilled vinegar would not coagulate it, as in the human; but it's cafeous matter was always made to appear of an extreme tenacity, when acids fomewhat concentrated were employed.

The greateft difficulty they found, was the feparation of the butter from the cream; and as Venel has obferved, from the fmall quantity of cafeous matter this milk contains, the nutritive property attributed to it muft depend lefs on the abundance of the principles which enter into it's compofition, than on the real manner in which they exift in it. With refpect to the ferum, thefe two chemifts found, that the fugar obtained by the firft cryftallization was covered and mixed with a faline matter, which they took to be fulphat of lime; and this is the only milk which afforded them a falt of this kind.

Contains fulphat of lime.

Since this milk appears to have been the firft from which an ardent fpirit was obtained, it may be thought neceffary to give fome account of it.

An ardent fpirit firft obtained from it.

It has been obferved by travellers, that the different hordes of Tartars have for many ages been accuftomed not only to prepare an agreeable acefcent liquor from the milk of the mare, to which they give the name of kumifs, but that they are able to extract by diftillation a very ftrong fpirit from it. The method, however, in which this was done remained unknown; and we are informed by Grieve, that when he was in Ruffia, it was with great difficulty he obtained the method of making it. He

has given the following account of the method uſually practiſed in the preparation of kumiſs by the Beſchkir Tartars. Take any quantity of freſh mare's milk, add to it one ſixth part of water, and pour the mixture into a wooden veſſel. Uſe then as a ferment one-eighth of the soureſt cow's milk, but a ſmall portion of old kumiſs is beſt; cover the veſſel with a thick cloth, and place it in a moderate temperature; when on repoſing twenty-four hours, a thick ſubſtance will be collected on the ſurface, which is to be beaten with a ſtick until it is intimately mixed with the fluid part. After repoſing another twenty-four hours it is put into a narrow veſſel, and ſtirred until it is perfectly homogeneous; in this ſtate it is called kumiſs, and has an agreeable taſte, which is a compound of ſweet and ſour. It is ſtirred every time it is uſed. Grieve was told, that if this be put into cloſe veſſels, in a cool place, it will keep three months or more.

We are informed, likewiſe, by Eaton, who was many years reſident both in Turkey and Ruſſia, that the Arabians and Turks have a preparation ſimilar to the *kumiſs* of the Tartars; by the firſt it is called *leban*, by the Turks *yaourt*. It is made by putting ſome of the old ſort to new milk made hot over the fire, when in a few days, more or leſs, according to the temperature of the atmoſphere, it becomes coagulated into an uniform conſiſtence, and of a moſt pleaſant acidulous flavour; the cream is in great part ſeparated, leaving the curd light and ſemitranſparent; and the whey is much leſs ſubject to ſeparate than by our method of uſing rennet for the purpoſe of cheeſe making.

"Yaourt," ſays Eden, "has this ſingular quality, that left to ſtand it becomes daily more ſour, and at laſt dries, without entering the putrid fermentation. In this ſtate it is preſerved in bags, and in appearance reſembles preſſed curds after having been broken by the hands; and

this dried yaourt, when mixed with water, becomes a fine cooling drink, or food." Fresh yaourt is an article of food amongst the natives, and it appears that Europeans soon become fond of it. The same gentleman informs us, that no other acid will make the same kind of curd, for after the acetous fermentation is over, the whole becomes putrid; that in Russia they put their milk in pots into an oven, and let it stand until it becomes sour, and this they use as an article of food, or make it into cheese; but it has none of the qualities of yaourt, though when new resembles it in taste.

This yaourt or leban is so valuable an article with the people, and is looked upon with such high consideration, as to give rise to a story of their first having received it from the hand of an angel, who taught Abraham how to make it, and that the angel brought a pot of it to Hagar.

With respect to the knowledge the Tartars had of extracting a spirit from this kumiss, we are informed by Marcus Paulus, that it was known to them even in the thirteenth century; to this spirit they gave the name of arki or ariki. We are informed by Pallas, that when they are in want of mare's milk they use that of the cow; but they prefer the kumiss, from it's containing a greater quantity of spirit, viz. one third of the whole; whilst the milk of the cow only affords two ninths. The Kalmuc Tartars call that from the mare tschigan, and that from the cow arjan or airer. This report of Pallas is confirmed by Beretshonshys, who accompanied Lepechin and some other academicians in their travels into Siberia and Tartary, and who published in 1778, at Strasburg, a dissertation on the ardent spirit to be obtained from milk. As authors have differed respecting the absence or presence of some of the component parts of milk in making this spirit, Oseretskowsky made some experi-

ments on this ſubject, and found that the milk muſt not be deprived of any of it's parts; he found, that the milk when deprived of it's buttter gave no ſpirit, neither of itſelf, nor by the addition of a fermenting ſubſtance; that imperfectly deprived of it, and likewiſe of moſt of it's caſeous matter, the whey afforded very little ſpirit after the acetous fermentation; and, on the contrary, milk that had been fermented by conſtant agitation in a cloſe veſſel, without any alteration of it's parts, produced the moſt ſpirit; and that a ſtill larger proportion was obtained, if the fermented milk was not immediately diſtilled, but left to ſtand ſome time, as it became much milder reſpecting it's acid. He took ſix pounds of cow's milk, put it into a glaſs with a narrow mouth, let it remain in it two months, ſhaking it well two or three times a day. During the agitation a great quantity of an aerial gas was extricated, and on the ſurface there was a white maſs collected, full of air bladders, which diſappeared on ſhaking; at length, the cream united again with the caſeous parts and whey, and perfectly reſembled freſh drawn milk in colour. There being no more air, the odour was very ſour, and the liquor not unpleaſant, but ſtrongly acetous and ſomewhat vinous to the taſte. He then let this lacteal wine ſtand a fortnight longer, in a well cloſed bottle, when he found it was become much milder, and approached the lacteal ſpirit in taſte. By repeated diſtillation he obtained three ounces of a very ſtrong ſpirit, which, on inflammation, loſt one half. It is now found that all milks contain more or leſs of this ſpirit; and it was remarked by Macquer, long ago, that the human milk on ſtanding acquires in a ſhort time a vinous ſmell which is not unpleaſant; and Voltelen has found, that on diſtillation, the human milk affords a much greater quantity of a gaſeous fluid than any other milk.

General reflections.

From the analyfis and phyfical properties of the different forts of milk, it appears, that their odour, favour, and confiftence, are fuch nice diftinguifhing characters, as to make it very difficult to lay hold of them, unlefs by a further comparifon. They all poffefs volatile principles, the nature of which we are ignorant of; for neither the odoriferous particles, nor thofe which give them flavour, have been obtained, unlefs in combination with water. From the difference, however, of their ftriking the organs of fenfe, we may conclude, that they muft neceffarily differ amongft themfelves. They all afford *cream*; but this, which is thick in the milk of the cow, is ftill more fo in the goat's and fheep's; whilft in human, afs's, and mare's milk, Parmentier always found it lefs abundant and more fluid, which make them approach nearer to each other, preferving, however, fhades by which they may be diftinguifhed.

In the various kinds of *butter* the differences are ftill more marked than in the cream; that of the cow, for inftance, feparates more eafily, and once feparated, is no longer mifcible either with milk or water; in confiftence it is generally pretty firm; the butter of the goat feparates with the fame facility and agrees with it in confiftence, but it is conftantly more infipid in tafte; whilft the butter of the fheep, although abundant, remains foft in all weather. As to the three other milks, although Parmentier was not able to extract the butter, he has no doubt of it's exiftence.

With refpect to the *cafeous matter*, it differs ftill more; that of the cow firft appears in a gelatinous form, being as yet impregnated with the whey in which it was formed; when feparated, it becomes in fome meafure fibrous. The curd of the goat has nearly the fame properties; whilft that of the fheep is always of a vifcous confiftence. In the human milk, the cafeous matter

never ſeparates ſpontaneouſly in a homogeneous maſs; it is always in a divided ſtate, preſerving after it is collected a ſort of creamy unctuoſity. That of the aſs has indeed a gelatinous appearance, but deprived of it's whey it loſes it in ſome meaſure; whilſt the curd of the mare reſembles it by forming in a maſs, but with greater difficulty.

It appears, therefore, a general rule may be eſtabliſhed, viz. that every ſpecies of milk incapable of furniſhing caſeous matter under a gelatinous form by ordinary means, will never afford butter to be compared to that of milk, the coagulum of which is well characteriſed; as is evident from the human, aſs's, and mare's milks, which coagulate ill, and afford butter with difficulty; whilſt thoſe of the cow, goat, and ſheep, which coagulate well, always produce firm butter, and with the greateſt facility.

With reſpect to the *ſerum* of theſe different milks, it varies as to quantity and ſavour, and may be obtained clear and colourleſs when no recourſe is had to fermentation or the fire. It is afforded in large quantity by the aſs's, mare's, and human milks, whilſt the goat's and cow's give leſs, and the ſheep's leaſt of all.

It appears, from Parmentier's experiments, that of all the eſſential parts which conſtitute the different milks, the ſaccharine part was the only one in which no difference could be obſerved; it had the ſame ſavour and colour in all, and may be properly denominated the *eſſential ſalt of milk*.

With reſpect to the milk of animals under diſeaſe, although it is conſtantly undergoing changes in health, theſe changes are infinitely more ſenſible when they are ill; but it appears, the moſt curious circumſtance is, that the alteration principally takes place in the caſeous part, which is the only part in milk that is really animalized;

and it appears further that what happens to milk, takes place equally in all animal fluids; thus in the blood, the bile, and the urine of an animal under difeafe, it is always the lymphatic part that undergoes a fpecies of decompofition; whilft the ferous and faline parts fuffer no change. Parmentier obferved, that the change in the cafeous part of milk varied according to the fpecies of the difeafe.

From the experiments of Stipriaan on the above milks, we have the following obfervations: he found the milk of the afs to be the moft *aquecus*; then followed that of the mare, the human, the cow's, the goat's, and leaft of all was that of the fheep.

With refpect to *cream*, the fheep's afforded the moft; then the human, the goat's, the cow's, and the afs's and mare's gave the leaft quantity.

Of *butter*, the fheep's produced the largeft quantity; then the goat's, the cow's, and the human milk.

Of *cheefe*, the fheep's had the preference; then the goat's, the cow's, afs's, and the human milk, whilft the mare's gave the leaft quantity.

The moft *fugar* was extracted from the milk of the mare; then followed the human, the afs's, and the goat's, the fheep's gave lefs, and the cow's leaft of all.

Such are the obfervations of chemifts on the milks of various animals; from the analyfis of which, Parmentier has divided them into *two claffes*; *the one clafs* comprehends thofe milks which abound in ferous and faline parts, as that of the afs, the mare's, and the human; *the other*, thofe which are rich in cafeous and butyraceous parts, as thofe of the cow, the goat, and the fheep; "in fhort," fays that experienced chemift, "it marks the fpecies which is to be preferred, in fuch and fuch circumftances, in order to pafs from one kind to another, and even fucceffively from the ufe of one milk to another, without being expofed to any inconveniency."

Whatever may have been the different opinions of authors with respect to the means of perfecting the butyraceous and caseous parts of milk; there is no doubt but that the means of increasing it's quantity, and of making it excel in quality, is to nourish the animals well from which it is drawn; by keeping them clean; often renewing their litter; milking them at regular periods; and procuring for them the best food. The experiments of Parmentier have, likewise, proved to him, that milk always participates of the individual from which it is drawn, as well as of the aliments which have served for it's nourishment. It has long been observed, that plants communicate to the milk their particular savour and odour; thus, bitter plants are said to give it their bitterness; the garlic it's strong and disagreeable taste; that colour is given to it by some plants, as the saffron; and their purgative quality by others; that Indian corn gives it a sweet savour; and the more aqueous plants render it aqueous and insipid. It is, however, very well known, that all plants do not contain sugar in the same quantity, whilst many do not contain it at all; which seems to prove, that from it's constancy in the milk of animals, the animal system, as well as vegetable, has the property of producing it. "But if the savour of the milk," says Parmentier, "(independently of the peculiar nature of the animal), be owing to the reunion of the different principles that constitute this fluid; it is not less true, that these principles receive, on the part of vegetables, characters which are in some sort indelible. If plants contain, for example, mucous matter in abundance, the milk will give a great deal of caseous matter, and it's savour will be insipid or sweet. If, on the contrary, they are very aromatic, the butter will be sapid, from the affinity of the *esprit recteur* with the oily matter. In the same manner the milk will be coloured, if the plants contain a colour-

ing matter, foluble in one of the principles; and it will abound in whey or ferum, if the plants contain much humidity. In fhort, all the products will be more fine, more folid, and more perfect, according to the tenuity of the oily, mucilaginous fubftances, and to the coriaceous, hard, and fibrous ftate of the plants, which concur to their formation. This being admitted, it is eafy to fee, why the moft perfect butter, and the moft efteemed cheefes, are made from milk of cattle nourifhed in meadows where many odoriferous plants grow; and when thefe meadows have loft, by exficcation, their perfume, and their fuperabundant humidity, they give a lefs delicate and more firm butter; whilft cows, furnifhed fimply with the ftalk and leaves of the maize, give always a fweet milk, an infipid and firm butter, on account of the infolubility of the faccharine body in the butter, of the abfence of the aromatic part, and of the folidity of the vegetable. It will further explain, why the milk of the cow fed by potatoe tops, which are more aqueous than maize, gives equally an infipid butter, but of a lefs firm confiftence; why the cruciform plants communicate a ftrong tafte to butter, whilft the whey is almoft infipid; in fhort, why cows, that feed in moift places, give milk lefs rich than thofe feeding on high and open paftures. If, therefore, we wifh to make the butter and cheefe of cows fed in the firft pafture more perfect, fome aromatic plants muft be added to their common food; whilft fucculent and inodorous plants muft be added to thofe nourifhed in the fecond; for good paftures depend as much on the foil and afpect as on the variety of plants of which they are compofed. To conclude; the foundation of the opinion of thofe authors, who fay, that manipulation does every thing refpecting the quality and the quantity of butter and cheefe, and the paftures nothing, is totally overthrown by reafon and experience; for the influence

of vegetables on the nature and quantity of theſe two products are evident, as well as that of the proceſſes employed to facilitate them."

Jacquin's Elements of Chemiſtry, p. 311. London, 1799.—Macquer's Chemiſches Wœrterbuch, von. G. Leonhardi, art. milch.—Anderſon's Eſſays on Agriculture, vol. 2. p. 70.—Beckmann's Beytræge, 3 tom. Leipſig, art. butter, 1783.—Pliny's Natural Hiſtory, London, 1634.—T. Voltelen de Lacte Humano Obſervat. Chimicæ. Lips. 1775.—J. Bergius Verſuche mit Frauenmilch, tranſlated from the Swediſh, in Crell's neueſt. Entd. 1. ſ. 57.—G. Aug. Lichtenſtein's abhandl. vom. Milchzucker, Brauns. 1775.—Annal. de Chim. tom. 10. p. 206.—A memoir by Dr. Grieve in the Tranſ. of the Royal Society of Edinburgh, for 1788.—Sur le Sucre de Lait naturel par M. Jahrig. Journ. de phys. ſem. 2. p. 368, 1791.—Eton's Survey of the Turkiſh Empire.—Rouelle in the Journ. de Médecine, mar. p. 250, 1773.—Scheele's works.—Hermbſtadt's chem. Unterſuch. des Milchzuckers in Crell's n. Entd. tom. 5.—Mémoir pour determiner par l'examen comparé des prrietes phyſiq. & chimiques la nature des diff rens laits, &c. par. Meſſrs. Parmentier and Deyeux, ſem. 2. p. 361 415. Journ. de phyſique, 1790.—Obſervations ſur les caves & fromages de Roquefort, par M. Chaptal, an. de ch. p. 31. tom. 4.—Sur le beurre & la crême du lait de vache, par. M. Fourcroy, ibid. p. 166. tom. 7.—Obſervations on the properties commonly attributed by medical writers to human milk, &c. by Jos. Clarke, M. D. p. 171. Tranſ. of the Royal Iriſh Acad. for 1788.—Experiments des Meſſrs. Stipriaan, Liviſcius et D. Bondt, in the Mém. de la Societ. de Méd. à Paris, 1787 and 1788, tranſlated into German in Crell's Chemiſche Annalen, ſ. 8. p. 138. 1794.

GASTRIC JUICE.

A menſtruum of a peculiar kind.

The gaſtric juice, when pure and in a healthy ſtate, is a thin, tranſparent, uninflammable fluid, ſecreted into the ſtomachs of animals by certain glands or veſſels ſituate in the coats of that viſcus, and forming a menſtruum of a peculiar kind, for the digeſtion of the various aliments.

Neither acid nor alkaline.

Action of reagents upon it.

It has no ſmell, is of a weak ſaline taſte, and colourleſs as water. It is neither acid nor alkaline, conſequently does not change the colour of litmus or of violets. It unites perfectly with water. When mixed with alcohol, an animal portion of it is precipitated in the form of a coagulum, in ſmall quantity; by Plenck ſaid to be of an albuminous nature, by others to be gelatinous.

Does not become putrid.

It neither effervesces with acids nor with alkalis, nor is coagulated by them. It is more difficultly frozen than water. It undergoes neither the acetous nor putrid fermentation.

Curdles milk.

It curdles the caſeous part of milk. It diſſolves vegetable or animal matter, or both, according to the nouriſhment of the animal. From the experiments of Carminati, it diſſolves iron, crude antimony, the flowers of zinc, and corroſive ſublimate; but has no effect on copper, cinnabar, or ſulphur. It is highly antiſeptic.

Diſtilled.

It is eaſily evaporated, and by a gentle diſtillation in a water bath, it affords nothing but water, which is neither acid nor alkaline; the remainder is of an animal nature, containing a little muriat of ſoda; hence, the gaſtric juice when pure, and taken from the human body in a ſtate of health, is compoſed of water, muriat of ſoda, and an animal ſubſtance, which, according to

ſome, affords phoſphat of *ammonia*. In the ſtate in which it is generally found in the ſtomachs of animals, it varies more or leſs in it's properties, not only in the ſame animal at different times, but in thoſe whoſe organs of digeſtion are different in their ſtructure, and in theſe the variety is ſtill greater. Much likewiſe depends on the nouriſhment, powers of digeſtion, and other circumſtances difficult to explain. Thus, it may be generally laid down as a rule, that the gaſtric juice in the *carnivorous* and *graminivorous* claſſes of animals, which have only one ſtomach, is acid, and colours the ſyrup of violets red. When impure is found in ſome animals acid.

In the *omnivorous*, ſuch as man, whoſe food is compoſed both of vegetable and animal diet, it is neutral. In others neutral.

In the *graminivorous* ruminating animals with four ſtomachs, and particularly in the adults, it ſoon becomes putrid, and colours the ſyrup of violets green. In others alkaline.

It appears, however, from the experiments which have been made on the different gaſtric juices, that they have all of them three properties in common, viz. they diſſolve vegetable and animal ſubſtances with more or leſs facility; coagulate the caſeous part of milk; and poſſeſs an antiſeptic quality.

A more minute examination of the properties of the different gaſtric juices has been made by Carminati, Brugnatelli, and Macquart.

According to Carminati, the gaſtric juice of the *carnivorous* claſs of birds, ſuch as falcons, hawks, herons, and owls, differ both in denſity and colour; it has, however, in all, a bitter ſaline taſte, is evidently acid, and examined by the moiſt way, beſides water, contains a dark coloured very bitter reſinous matter, with a penetrating and peculiar odour; an animal ſubſtance of the ſame colour, very little ammoniacal, and a greater quantity of marine ſalt. In the dry way, the products of diſ- Experiments on the gaſtric juice of the carnivorous claſs.

tillation were much water, an acid, a few drops of an acrid, fat oil, adhering to the neck of the receiver, with a faline fubftance affording the fmell of ammonia. The caput mortuum gave cryftals of marine falt, and the incinerated afhes a little iron and fome calcareous earth.

The experiments of Brugnatelli on the gaftric juice of the owl agree pretty much with thofe of Carminati; he found it to be lefs aqueous than that of animals which feed on vegetables, of a dark colour, turbid, and a fharp bitter tafte, and a penetrating, acid, rancid fmell; he found it contained likewife a refinous matter, a free acid, and a little common falt united to an animal matter; it is very antfeptic. Carminati found the gaftric juice of graminivorous nonruminating animals, as the rabbit, &c. to have the fame properties, and to be fimilar in it's contents to that of the carnivorous.

Omnivorous clafs.

With refpect to the *omnivorous* clafs, fuch as man, cats, dogs, crows, &c. he obferved that their gaftric juice was neutral when nourifhed with flefh and vegetables, but if only with flefh, it became perfectly fimilar to the carnivorous gaftric juice; on diftillation, he obtained a water that fometimes became alkaline, owing as he thought to it's being impure, for when frefh the water was infipid; the reft was a phlegm, a little black and acid oil, and the caput mortuum refembled that of the preceding clafs.

Brugnatelli found an acid in all animals of that clafs, or in cats and blackbirds, &c. and having fed them with flefh a few days, it refembled that of the owl. He kept an owl for ten days on vegetables; it, however, did not lofe it's acid, but only became more aqueous. He attributes it to it's drinking water, which is not the cafe when fed on flefh. He found the gaftric juice acid in the granivorous fowls, fuch as pigeons, quails, ducks, hens, &c.

Scopoli triturated ſome gaſtric juice of the cow with cauſtic potaſh and quick lime, and he diſtinctly perceived an urinous and acid odour. It ſenſibly changed violet ſirup green; poured into a nitrous ſolution of ſilver, it afforded a precipitate that reſembled the muriat of ſilver. Two drachms ſlowly evaporated, left two grains of a grey matter, which had a diſagreeable odour, deliqueſced in the air, and did not efferveſce with acids. On diſtillation, it afforded an empyreumatic phlegm, whilſt a white matter was attached to the ſide of the retort, which, when triturated with lime, manifeſted an urinous odour; the reſiduum had the conſiſtence of an extract, had an empyreumatic ſmell, ſaline taſte, bitter and nauſeous; it neither efferveſced with acids nor alkalis, and put into a ſolution of potaſh, there aroſe a very penetrating odour of volatile alkali. He concludes that pure gaſtric juice is compoſed of a ſaponaceous and gelatinous animal ſubſtance, of ſal ammoniac, and of an earth ſimilar to that which all animal fluids afford. "Since it is evident," ſays Morveau, "that this chemiſt has only judged of the nature of the acid by the appearance of the ſaline precipitate of ſilver, much is wanting to make the proof ſufficient, ſince other acids likewiſe precipitate this metal. Theſe doubts are the more admiſſible, ſince the author carries the conſequences of theſe reſults to a greater length; he goes ſo far as even to ſuſpect that the muriatic acid is *the product of the vital power* in animals; he looks on the fact as proved, if the gaſtric juice of animals nouriſhed with vegetables likewiſe affords ſal ammoniac; and Spallanzani aſſures us, that after having fed five crows for fifteen days ſolely on vegetables, he found the gaſtric juice to afford likewiſe a precipitate of luna cornea." Other experiments are neceſſary, and better proofs required before ſo new a ſyſtem can be received, or before the nature of the

acid can be determined, which, in the gaſtric juice, puts the ammonia into the ſtate of a neutral ammoniacal ſalt.

Graminivorous claſs.

The *graminivorous* ruminating claſs, according to Carminati, is compoſed of ſimilar principles to the preceding, if a portion of ammoniacal ſalt be excepted in the gaſtric juice, which he believes to be in reality acid. He has, however, found the gaſtric juice of lambs, ſheep, goats, and herbivorous calves, taken a long time from the living or dead animal, very often alkaline ſo as to effervefce with acids; but the alkali he looks upon as the product of the putrefaction of the herbs, which ſojourn a long time in the ſtomachs of theſe animals; he founds his opinion on the following obſervations: 1ſt. the gaſtric juice of theſe animals is often found acid. 2d. it is always ſo in ſucking calves, and even in the ox, after having faſted ſome time, or rather after a good and perfect digeſtion. 3d. freſh graſs digeſted in pure or ſalt water, at a heat between twenty-five and thirty of Reaumur, becomes alkaline in a few days. 4th. ſimilar graſs being plunged in the gaſtric juice of ruminating animals, whether acid or alkaline, the acid juice became alkaline in the ſpace of four days; and 5thly, the gaſtric juice of ſheep, which had faſted a long time, was found acid. On diſtillation, the gaſtric juice of this claſs at firſt afforded an alkaline, and afterward an acid water; when, on concentrating this water, he collected a little acid from it which he looks upon as an animal acid. It likewiſe afforded ſome ammoniacal ſalt, which, however, is not always the caſe, and an empyreumatic oil; the reſt was ſimilar to the preceding.

According to Brugnatelli, the gaſtric juice of this claſs, ſuch as the ſheep, &c. is found in all the four ſtomachs, but the pureſt in the firſt: it is very aqueous, in oppoſition to that of the carnivorous claſs, a little turbid, and of

a pale earthy colour: it confifts of a great watery portion of volatile alkali, of an animal extractive matter, with a good deal of fea falt: it is bitter, fharp, and faline to the tafte: it eafily putrifies in fummer, and in four or five days fmells like rotten eggs.

Macquart has likewife made fome experiments on the gaftric juice of the ox, the fheep, and the calf. The juice from the ftomach of the ox he collected when fafting; it fmelled like ftraw, to which was fometimes added a refemblance to mufk; each animal afforded one pound and half, which he filtered and preferved in bottles for ufe, but it was impoffible to procure it clear and tranfparent. He found on analyfis,

1ft. That one pound four ounces gave ten grains of a lymphatic matter, having the fame properties as that of blood.

2d. $16\frac{6}{7}$ of phofphoric acid.

3d. 5 grains of phofphat of lime.

4th. 2 ditto of refin.

5th. 14 ditto of fal ammoniac.

6th. 29 ditto of muriat of foda.

7th. And a fmall quantity of extract remained difficult to appreciate.

8th. The quantity of water was one pound, three ounces, fix drachms, and 67 grains and half.

Total 1 lb. 4 ounces.

The ftomach of the fheep contains from five to eight ounces of pure vifcous gaftric juice, of a deep green colour, and more difpofed to putrefaction than that of the ox or calf; from this he feparated the lymph by means of heat; he found that volatile alkali difcovered the prefence of the phofphat of lime; that fpirit of wine rendered the fal ammoniac and refin fenfible; that lime, by

the weight of the precipitate it affords, indicates that of the disengaged phosphoric acid; and lastly, his analysis procured the presence of marine salt. One pound of this gastric juice afforded

Lymph	64 grains.
Phosphat of lime ..	10
Muriat of ammonia	13.20
Resin	10
Phosphoric acid ..	10
Marine salt	13.18
Extract	2
Water ...... 15℥	3ʒ 62
Total	1lb.

Hence, according to Macquart, the gastric juices of the ox and sheep are of the same nature; but the last contains more serum and extract, and is more liable to the putrid fermentation in consequence.

The stomach of the calf Macquart found to contain from four to six ounces of gastric juice, always mixed with a reddish grey matter with much hair. When filtrated it has a light grey colour, precipitates lime water, and affords a white deposit by the addition of volatile alkali. It begins to ferment in five or six days exposed to a temperature of 20° of Reaumur. It then deposits a white powder of a disagreeable smell. It contained phosphat of lime and sulphat of lime; exposed to a boiling heat, it deposits but very little coagulated lymphatic matter. One pound of this gastric juice afforded

Lymph	4 grains
Dry jelly	24
Selenite	6
Phosphat of lime	10
Sal ammoniac	12

Lactic acid	....	48 grains.
Marine falt	....	40
Phofphoric acid	....	4

without reckoning the fugar and the extract contained in the juice. Hence it appears that the gaftric juice of the calf differs from both the preceding, by containing a greater quantity of gelatinous matter, fugar, and felenite. The difference is greater from the lactic acid it contains, which is in great abundance. Macquart found, that the proportion of the principles in the gaftric juices of animals varies from their individual ftrength, their age, and more efpecially from the nature of the climate, in which he agrees with other chemifts; and he has determined that the gaftric juice of ruminating animals contains the phofphoric acid, and not one *fui generis*, and in this he has been fupported by Struve.

OF THE ACIDITY OF THE GASTRIC JUICE.

Acidity of the gaftric juice.

The property which rennet has of coagulating the cafeous part of milk was known in the time of Diofcorides; and as it has been remarked that acids had the fame effect, it was natural to fuppofe they would attribute this property in rennet to it's poffeffing an acid. Many celebrated writers have likewife remarked, that the gaftric juice of carnivorous animals is acid. Thus Floyer found it acid in carnivorous birds; Marfigli, in the eagle; Viridet, in carnivorous fifh; and Lorenzini in the cramp-fifh; but all have attributed this acidity to the unnatural ftate of the gaftric juice. With refpect to rennet, which is the dried ftomach of the calf; it is the fourth ftomach of the ruminating tribe only that poffeffes this quality.

The juice found in the craws of birds has not this property. Macquer looked upon it's coagulating property to arise from the remnant of sour milky matter, which he thought was sufficient to coagulate the milk. It is, however, now proved that this property arises from the nature of the gastric juice itself; that this virtue is communicated even to the coat of the stomach itself, and to a certain point to the neighbouring parts which are most impregnated with it. It therefore remains to examine whether this property arises from the gastric juice being an acid, or from it's own peculiar nature. Morveau digested at different times parts of the interior tunic of the stomach of the calf, both in hot and cold water, previously distilled; he then poured some spirit of wine upon it, which occasioned a precipitate, and he always found that the filtrated liquor sensibly changed blue water to a red. According to Scopoli, the human gastric juice is sometimes acid, and at other times not; which is proved by the acid or insipid eructations, either when fasting, or during the time of digestion. The gastric juice therefore, being found so very generally in a state of acidity, Morveau has placed it in the French Encyclopedie amongst the animal acids, under the name of the *gastric acid*, doubting at the same time whether it be an essential part of it's nature. From the experiments of Spallanzani, this acid quality depends on the aliments, for birds of prey never gave the least sign of any acidity; and the same may be said of frogs, serpents, and fish. He found that when the gastric juice of crows afforded him signs of acidity, they had been nourished on vegetables; and the same observation might be applied to dogs, graminivorous animals, and the gallinaceous class. Shells and coral were likewise rendered up by carnivorous birds, without having undergone the least alteration, which would not have been the case if the juice had contained an acid. Spallanzani likewise swallowed calca-

reous ſubſtances encloſed in tubes, which he found were only diminiſhed when he uſed vegetable food or fruits; and that when he fed on animal food they were always untouched. The teſtimony of Goſſe of Geneva may likewiſe be adduced, for he was not able to ſuſtain any length of time the uſe of crude vegetables, from the frequency of the acid eructations they occaſioned. In ſhort, Monck, after having obſerved that calcined magneſia was not in any way ſoluble in the gaſtric juices of different animals, affirms, that he has ſeen the gaſtric juice vomited by a hypocondriac perſon to be acid, efferveſce ſtrongly with crabs eyes, and diſſolve two grains of calcined mganeſia.

Spallanzani is of opinion, that in it's natural ſtate the gaſtric juice is neither acid nor alkaline, but neutral. His reaſon for thinking ſo is, that the acid which is manifeſt at the beginning of digeſtion in the ſtomach of ſome animals, conſtantly diſappears toward the end of that proceſs, and is very inconſiderable; and that when gaſtric juices are poured into a ſolution of the carbonat of potaſh, there never ariſes any efferveſcence; which proves that they either contain no diſengaged acid, or that the acid is not ſufficiently powerful to diſplace the carbonic acid.

The difference in the reſult of the experiments of thoſe who have inveſtigated this liquor, it is evident, muſt have ariſen from the difficulty of procuring it in a pure and healthy ſtate, for it would appear that the acidity is owing entirely to the food. It is well known that vegetables, when expoſed to a heat equal to that of the ſtomach, are very prone to the acetous fermentation; and that on the contrary, animal food under the ſame circumſtances tends to the production of volatile alkali; and theſe will take place in proportion to the weakneſs of the ſtomach; or if the quantity of food taken in exceeds the power of the gaſtric juice to prevent them; for it is prov-

ed from experiment, that this juice when pure is much diſpoſed to counteract either, and in weak ſtomachs, ſuch as children, the contents are often four, as is eaſily known from the acid eructations and the uſe of magneſia. Likewiſe, that food in carnivorous animals, when taken in too great quantity, is very apt to tend toward the putrid fermentation, is evident from the putrid eructations, and the diſagreeable ſmell of dogs and other animals of that claſs, which are apt to eat voraciouſly. It would ſeem, therefore, that both the acid and the alkali, when found in a ſeparate ſtate in the gaſtric juice, proceed from theſe cauſes; and the ſame thing happens in vegeto-carnivorous animals, where the neutral ſalts are found. To theſe it may be added, that it's not being always found to have acid properties, is a proof that they are only accidental, and like the alkaline, only proceed from foreign cauſes; and that when found in a neutral ſtate, it does not appear to alter it's properties as an animal and vegetable menſtruum, which would be the caſe if it's powers depended on it's acidity. But the experiments of Fordyce and Hunter, appear to put the matter out of all doubt. Dr. Fordyce found, that when dogs had bread for their food, which is not their natural aliment, in about four hours after, an acid was diſcovered on examining that part which had paſſed into the beginning of the duodenum; but on changing the food for meat, no acid enſued. The ſame with reſpect to ſheep and cows, the natural food of which is vegetable; for the matter at the beginning of the duodenum in theſe animals ſhowed not the leaſt trace of acidity, as it neither changed the colour of red cherry juice, nor litmus, which are the moſt delicate teſts. Hunter, about the ſame time, found no acid in the previous or digeſtive ſtomach of rabbits, and other animals of the ſame kind.

Dr. Fordyce even found, that when the ſtomach was in perfect health and vigour, if putrid meat was conveyed

into it, as being ſwallowed by a dog, it was rendered perfectly ſweet again. The inhabitants about the mouth of the Orange river, in Africa, live always on animal food, which is often putrid, yet they are ſtrong and healthy; and maggots that live upon and in putrid maſſes, are themſelves perfectly ſweet, and their fluids are entirely free from the leaſt taint of putrefaction.

METHODS OF PROCURING IT IN IT'S PURE STATE.

SINCE many errors may have ariſen from the difficulty of procuring the gaſtric juice in a pure ſtate, from it's being eaſily affected by acid or rancid ſubſtances taken into the ſtomach, or from it's admixture with the bile from the duodenum, many methods have been invented to procure it in a ſtate proper for experiments; three of which I ſhall deſcribe as being the leaſt liable to miſlead the chemiſt. To procure the gaſtric juice in it's pure ſtate.

The *firſt* and moſt ſimple method is to take it after the death of the animal; and if previous to this, it be ſuffered to faſt for ſome time, it will not only be obtained in greater abundance, but the danger of any admixture of the aliments will be decreaſed. It was in this manner that Spallanzani obtained 37 ounces of gaſtric juice from the two firſt ſtomachs of a ſheep, after it's faſting two days; it was of a green colour, which might proceed from a ſmall quantity of graſs remaining there, and which is a proof how difficult it is to procure it perfectly free from other ſubſtances. He likewiſe opened ſome young crows that had not flown, and found about half a ſpoonful, which was more than he could get from adults. This method, however, is very cruel, and will ſcarcely be attempted by the more humane philoſopher, whilſt he has other means in his power. 1ſt. method.

A *ſecond* method is by means of ſponges. Reaumur 2d. method.

made ufe of them without any defence, but Spallanzani placed them in little thin metallic tubes, pierced with fmall holes; thefe he made the animals fwallow. He obliged fome crows to take each eight of thefe tubes, fucceffively, when, in the fpace of three hours and a half, they were vomited up again. He collected from five crows 481 grains of gaftric juice, of a yellow, tranfparent, dirty colour, faline and bitter to the tafte, affording very little fediment if the bird had fafted, and which although expofed to the air for feveral hours, evaporated very little, and extinguifhed flame. This yellow colour and bitter tafte moft probably arofe from the bile, as well as the refinous matter which is found in the gaftric juice.

3d. method. A *third* method is to procure it in the morning, fafting, by exciting vomiting; in this manner, Spallanzani procured it twice, by irritating his throat with his two forefingers. At one time he got by this means one ounce thirty-two grains of a vifcous, foamy liquor, which, after having depofited a flight fediment, became as limpid as water; it was without colour, of a faline tafte, without any bitternefs, uninflammable, eafily evaporated on the coals in an open veffel, but in a clofe one kept during a month in a very hot Italian fummer, without either change of tafte or odour; the pain, however, which he fuffered from the irritation, prevented him from trying the experiment a third time; and Scopoli has remarked, that by this means only, the more fluid parts are obtained, as the thicker portion remains attached to the bottom of the ftomach, and is only to be procured by the more powerful emetics, fuch as tartar emetic, &c. A more eafy and profitable way of exciting vomiting, is that purfued by Goffe. This eftimable philofopher has the power of rendering the contents of his ftomach by fwallowing air, which acts as an emetic; by which means he can procure the gaftric juice in a much purer ftate than by diffections. To this it may be added, that Spallanzani has

remarked, that the eagle renders a confiderable quantity of gaftric juice fpontaneoufly, in a morning when fafting, exempt from foreign matter, of an afh colour, nearly as fluid as water; it is faline, bitter, uninflammable, and has the fame odour as other gaftric fluids; he procured about fix drachms of it every day, by placing a glafs veffel before the bird. Such are the principal methods by which this fluid may be obtained in as pure a ftate as it's nature and fituation will admit of; but there is reafon to believe, that the mucus and faliva which are conftantly mixing with it in the ftomach may alter it's properties, whilft the bile may be the caufe of it's refinous bitter tafte and yellow colour, which it is fometimes known to poffefs.

Experiments upon the gaftric juice in the ftomach.

Befides the methods juft related of procuring this fluid for the fake of experiments out of the body, others have been invented by which different experiments have been made on the powers of this fluid, whilft it remains in the ftomach, by which it's action on different fubftances may be better known, perhaps, than in any other fituation, and when extracted from it's natural vifcus. This was firft introduced by Reaumur, who forced fheep to fwallow fmall tubes of metal filled with grafs and other herbs. It was followed by Spallanzani, who has employed the fame method on a great number of different animals. The tubes were filled with the food peculiar to the animal, or with other fubftances, and were examined either on being rendered by the anus, or by exciting vomiting after a given time, or by opening the animal; whilft fome of the birds vomited them fpontaneoufly in a few hours after having taken them. Spallanzani and Goffe tried thefe methods on themfelves; The firft began by fwallowing fmall purfes of roafted or raw flefh, or filled with bread, &c. Afterward he took fmall cylinders of wood, pierced with holes, and covered over with linen;

but with respect to Goſſe, from the facility of rendering them at pleaſure, he was able to ſwallow different ſubſtances, to keep them as long in his ſtomach as he thought neceſſary, then reſtore them up again to obſerve and compare the progreſs of digeſtion; and he has made ſo many experiments on vegetable and animal matters, as to be able to form them into different claſſes, viz. Thoſe ſubſtances which appeared to him indigeſtible; thoſe in part digeſted; thoſe of eaſy digeſtion; thoſe which haſtened digeſtion; and thoſe which prevented or diminiſhed it.

It is ſuppoſed alſo by Brugnatelli, that the white matter which is generally found in large quantity in the excrements of carnivorous birds, and which differs very much in conſiſtence, which is ſoluble in water, and gives a ſtraw coloured liquor, is a portion of gaſtric juice, and may be of uſe in experiments. Such are the methods employed in experiments on the gaſtric fluid.

ANTISEPTIC QUALITY OF GASTRIC JUICE.

It's antiſeptic quality.

It has been obſerved that the gaſtric juice poſſeſſes an antiſeptic quality, by which it not only preſerves itſelf from putrefaction, but ſubſtances which are put into it. Various experiments on this power of the juice has been made, amongſt which the principal are thoſe by Jurine, Carminati, and Spallanzani. We are informed by Carminati, that the gaſtric juice of *carnivorous animals* was placed in veſſels expoſed to the air and heat of different ſeaſons; and that it always kept good and free from putridity until it became perfectly exſiccated. That when

In carnivorous animals.

this gaſtric juice was mixed with blood, or poured in different quantities on freſh and corrupt meats, it afforded various proofs of it's antiſeptic quality, either by preſerving them from corruption, or in correcting it after it had taken place; and it's action is the more certain and ſudden, the greater the quantity of the gaſtric juice employed, relative to the ſubſtance to which it is added.

Spallanzani has likewiſe proved the antiſeptic power of the gaſtric juice. He found that to produce artificial digeſtion, little or no ſolution takes place, unleſs the gaſtric fluid employed be expoſed to a briſk heat, but this heat is not neceſſary for it to retain it's antiſeptic powers. He found that the gaſtric juice of the crow and dog preſerved veal and mutton 37 days in winter, without it's being either conſumed or putrid; whilſt the ſame meats immerſed in water emitted a fetid ſmell on the 7th, and about the 30th day were changed into a very offenſive liquamen. Yet the gaſtric juice loſes at laſt it's antiſeptic quality, even though kept in phials perfectly well ſtopped, but it never becomes putrid itſelf. He found that fleſh which had an inſupportable ſtench when put into the gaſtric fluids of the dog, crow, owl and eagle, during the month of March, at a temperature of from eight to twelve of Reaumur, kept twenty five days, and was ſomewhat diminiſhed in ſmell, but not the leaſt diſſolved. That fowl and pigeon, in which putrefaction was far advanced, in the gaſtric fluid of a dog and falcon, in the month of June, was reduced to a jelly in 37 hours, and had loſt moſt of their diſguſting ſmell: hence heat is neceſſary in this caſe; and he found that fleſh which was become putrid in the craw of a cockerel, loſt it on arriving in the ſtomach. Animals of cold blood he found much longer in correcting the putrefaction of fleſh, from their ſlow digeſtive powers. Hence it appears from theſe experiments, that the various claſſes of animals, and

man among the reſt, are endowed with the power not only of checking the putrefaction of ſubſtances in the ſtomach, but alſo of correcting them when already putrid. It is an antiſeptic, however, which differs from other ſubſtances poſſeſſing that property; for they, while they keep away putrefaction, preſerve or reſtore the coheſion of the parts, whilſt the gaſtric fluid, being at once an antiſeptic and ſolvent, preſerves or corrects putrefaction by reducing bodies.

From this antiſeptic quality, the diſguſting manners of theſe animals, who delight in corrupted and putrid ſubſtances, onght no longer to excite ſurpriſe, for the food, however putrid, muſt be totally changed before it is converted into nutriment and animalized. In this manner the multitude of loathſome inſects and worms that feed on decayed carcaſes, and of birds and quadrupeds, ſuch as the crow, the kite, the vulture, the jackal and the hyena, that ſeem to find a pleaſure in tainted fleſh, may devour their ſavoury morſels; and whilſt other animals are flying from the miaſmata ariſing from ſuch putrid bodies, theſe may enjoy their abominable repaſts with impunity.

Omnivorous. In *omnivorous* animals, Carminati obſerved the ſame or nearly the ſame power in their gaſtric juice, as in the preceding.

Graminivorous. *Graminivorous*, ruminating, and nonruminating animals, were found poſſeſſed of the ſame antiſeptic quality in their gaſtric juice, as, the others when it was acid; but when alkaline, it corrupts very ſoon, and more or leſs ſo according as the heat is greater or leſs, and it's alcaleſcency more or leſs ſtrong.

We are informed by Jurine, that the gaſtric juice of the ox, in the common temperature, kept inodorous about 30 hours, that at the end of 48, it had contracted a fetid odour; mixed with fleſh, it corrupted in 8 hours.

In an ice houfe, and the bottle ftopped, it kept 14 days without change. It may be obferved, that from this antifeptic quality, fome phyficians have imagined that the gaftric juice might be of ufe as remedies whether externally or internally applied.

APPLICATION OF THE GASTRIC JUICE IN DISEASES.

The gaftric juice ufed as a medicine.

Jurine, of Geneva, Foggia and Carminati, have tried the effects of this liquor in different difeafes, and with various effects. We are informed by the firft phyfician, that, when applied *externally*, 1ft. the gaftric juice has the property of curing certainly and immediately the pains which arife from bad ulcers.

2d. That it ftimulates and deftroys difeafed flefh, and foftens the edges of callous ulcers.

3d. That it diffipates difagreeable and putrid odours arifing from difeafed parts.

4th. It diminifhes exceffive fuppuration, and gives it a healthy appearance.

5th. It accelerates the cicatrix. The experiments of Carminati appear to fupport thofe of Jurine; he found that the gaftric juice of rooks, and of the Royfton crow, kept omnivorous by nourifhing them with flefh and vegetables; perfectly cured old fetid ulcers, after having been bathed with it two or three times a day; that it produced a fenfation of heat during the two or three firft days of it's application. He found the gaftric juice of carnivorous animals poffeffed this property in an eminent degree, and although the heat it produces is greater than that from the crow, the cure is much quicker. He found it of

great uſe in bad venereal ulcers, in ſtopping the progreſs of gangrene, and in rendering the ichorous humour of the cancer more mild, taking away it's fetid odour, and diminiſhing the ſhooting pains of that diſeaſe. The experiments of Foggia ſupport thoſe of Jurine, and the great beneficial effects of the application of the gaſtric juice of graminivorous animals in the cure of ulcers is aſſerted by Dr. Harneſs. He has found it to ſucceed in more than 100 inſtances, where ſphacelus had occurred; and teſtimonies of it's peculiar good effects in ſimilar caſes are given by Jones, a ſurgeon to the naval hoſpital at Baſtia, and Read and Buck, two of his principal aſſiſtants. An inſtance of the cure of an ulcer by Dr. Harneſs is the following. Thomas Corben, boatſwain of the Egmont, on the 31ſt of July, 1796, had an ulcer on the right leg, ſix inches in length, and four in breadth; the margin of the ſurrounding integuments, with the much greater portion of the ſurface of the ulcer, were in a ſphacelous ſtate. The diſcharge was ſo acrid as to deſtroy every part it came into contact with, and it had inſinuated itſelf through the whole length of the gaſtrocnemius and ſoleus muſcles. The whole extremity was very tenſe, and the health of the patient much impaired. He had recourſe to the gaſtric juice of a bullock killed for the uſe of the ſhips, from which three pints of fluid were obtained. The ſurface of the ulcer was waſhed with it, and it was injected by a ſyringe into the ſinuſes, and ſuperficial dreſſings of lint applied. The third day after this application was begun, upon removing the dreſſings, the whole of the ſphacelated parts came away, and expoſed a large portion of the tibia, in two places. To theſe, lint dipped in the gaſtric juice was applied, which not only appeared to prevent diſcoloration and exfoliation, the uſual attendants; but, on the contrary, in the courſe of eight days the parts thus expoſed were covered with granulations,

and at the expiration of fourteen days, the whole of the foft parts were perfectly reunited, and the furface of the ulcers reduced to a fore of about two inches and half diameter, with granulations fmall, compact, and of a beautiful fluid colour. Nov. 10, it was perfectly healed, and the patient attended to the duties of the fhip. He took Peruvian bark, and ufed lemons and onions during the cure.

Ufed *internally* in indigeftion, fuch as in vomitings of acid and black matter after eating, and in other difeafes where the gaftric juice of the ftomach had loft it's energy, Carminati found it of great ufe. The dofe was one ounce of frefh juice from the ruminating clafs, taken daily. Where the organ itfelf was affected, it was of no ufe. The gaftric juice of carnivorous animals he found to be too irritating to an ulcer of the ftomach, until it had been diluted with water. He likewife cured intermittents with it, and raifed the dofe to three ounces in the day. He obferves that the juice of herbivorous ruminating animals, when acid, may be fubftituted for that of the carnivorous clafs, and is more eafily procured.

We are informed, that Carminati was capable of imitating the gaftric juice of the carnivorous clafs; he digefted for this purpofe two drachms of frefh veal in one ounce of fpring water, and added five grains of common falt; it was expofed to the heat of about 100° of Fahrenheit for fixteen hours, and the liquor was then decanted. By repeated digeftion with frefh flefh, he found it became much ftronger and more fimilar to the natural gaftric juice.

According to Struve, who fays that the phofphoric acid and volatile alkali are the two effential principles of the gaftric juice, a liquor may be made which produces a fimilar effect upon aliments.

DIGESTION.

If we look back into antiquity, we ſhall find that the earlieſt opinion on the cauſe of digeſtion was, that of putridity. It was by this proceſs that both Hippocrates and Empedocles ſuppoſed the food when taken into the ſtomach to be reduced to a proper ſtate for the ſupport of the animal ſyſtem.

Hippocrates and Empedocles.

Galen. Galen and his diſciples conceived an idea that it was brought about by heat.

Van Helmont. Van Helmont, whoſe wild conjectures can only be accounted for by the ſpirit and enthuſiaſm of alchemy, which raged in his time, attributed digeſtion to the vital energy of the ſoul, which reſided, as he thought, in the ſtomach.

Grew and Santarelli. Grew and Santarelli were of opinion, that the ſpirits which are poured forth from the nerves of the ſtomach ſerved for the concoction of the food.

Boerhaave. Boerhaave, who has in reality only attempted to reconcile the variety of opinions that had been propoſed before him, ſuppoſes there are two principal agents in this vital function, viz. the different fluids that are collected in the ſtomach, and the mechanical action of that organ. The ſecondary agents, he ſuppoſed, are heat, air, the nervous fluid, the remains of the food, and an incipient fermentation, oppoſing it in the extenſive ſenſe in which it was conſidered before him. With reſpect to the gaſtric fluid, his ideas appear to be indeterminate, and unſettled; he, however, conceived that it's action on the food was merely as a ſimple diluent, like water, when heated to the ſame temperature. He had no ſuſpicion of it's being a ſolvent, or that it was capable of acting upon the more tenacious and hard ſubſtances that were taken in as food.

According to Pringle and Macbride, digeſtion is carried on by a complete fermentative proceſs. The food divided by maſtication, and penetrated by the ſaliva, begins, as ſoon as it enters the ſtomach, to be agitated by that inteſtine motion which always accompanies fermentation; this motion is excited by the warmth of that viſcus, by the old remnants of the food, by the gaſtric fluid, and more particularly by the ſaliva, which is above all adapted to produce and promote this proceſs. They ſuppoſed that the firſt effect of this inteſtine commotion, is to raiſe the ſolid parts of the aliment to the ſurface of the gaſtric liquor, where they will be for ſome time ſuſtained by the air bubbles, which, on their ceaſing, muſt fall down again and be thoroughly incorporated with the fluids of the ſtomach. This mixture is rendered ſtill more complete by the periſtaltic motion, the alternate preſſure of the diaphragm and abdominal muſcles, and the continual pulſation of the adjacent large veſſels. In this ſtate the food paſſes into the ſmall inteſtines, where the fermentative motion produces ſtill greater changes by the aſſiſtance of the bile and pancreatic juices. It is then converted into chyle. Pringle and Macbride.

According to the opinion of Haller, the gaſtric juice is more or leſs acid in different animals; it's action on the food very much reſembles that of water, in which a little ſalt has been diſſolved, which, from experience, is known to poſſeſs a very great reſolvent power; and the conſequence is, that an incipient fermentation takes place which reduces the aliments to a pultaceous maſs. In animals that feed on ſeeds, this proceſs is aſſiſted by trituration. Theſe, with many other fanciful opinions, took place in their turn, when Cheſelden by chance happened to conjecture right, viz. that digeſtion was performed by ſome unknown menſtruum. This conjecture was confirmed by Reaumur and Spallanzani, who have proved the menſtruum to be the gaſtric juice by a number of experiments, a gene- Haller. Cheſelden. Reaumur and Spallanzani.

ral view of which it will be neceffary to give. Spallanzani made his experiments by introducing certain fubftances, fuch as raw vegetables, &c. enclofed in fmall perforated tubes, and caufing animals to fwallow them; he then either deftroyed the animal in order to examine it, or waited until it was vomited up. The animal kingdom may be divided into three kinds; thofe whofe ftomachs are *mufcular*, *intermediate*, and *membranous*; the laft clafs is infinitely more numerous than the two former.

Stomachs. Of animals with *mufcular* ftomachs, fuch as fowls, turkeys, ducks, geefe, doves, pigeons, &c. the food is feeds, fuch as wheat, barley, peafe, &c. When it is taken fpontaneoufly by thefe birds, it remains fome time in the craw, where it is macerated and becomes fofter; it is then conveyed into the ftomach or gizzard, which is compofed of very ftrong mufcles, capable of grinding not only the grain it receives, but is of fuch force as even to reduce fmall pieces of glafs, and blunt the points of needles; by this means the food is triturated and reduced very fmall; it is then converted, by the gaftric juice it meets with in this vifcus, into a pultaceous mafs called chyme. Spallanzani found, that the gaftric juice of this clafs digefts flefh, and that they are for the moft part both frugivorous and granivorous. He found it diffolved raw flefh, when bruifed, in about two days; but when entire, four and fometimes five days were neceffary. It diffolves grain only when bruifed; hence, in the gallinaceous clafs, trituration and the gaftric fluid in the gizzard, although Reaumur was of opinion it contained no menftruum, mutually affift each other; the former, by breaking down the aliments in a mechanical way, prepares it for the latter, which penetrates it, deftroys it's texture, diffolves it's particles, and difpofes them to change their nature and become animalized. Spallanzani thinks, that this gaftric fluid found in the gizzard proceeds chiefly from the œfophagus; the

chyme he found to be a femifluid pultaceous mafs, of a whitifh yellow colour. The tranfparency of this gaftric juice, in a ftate of purity, is little inferior to water, it is fluid, and a little bitterifh and faline. It retains out of the body, when warm, the power of diffolving animal and vegetable fubftances; but it muft be frefh, for if kept in veffels, particularly if open, it lofes it's efficacy; it muft not have been ufed for experiments, and likewife a heat equal to that of the bird is neceffary, otherwife it has no more effect than water.

The ruminating animals of the third clafs, fuch as fheep, oxen, &c. very much refemble this clafs of birds in their manner of digefting fubftances; in both, the gaftric fluid requires an agent capable of breaking down the food, before it can diffolve it. The hay and grafs, in the ruminating tribe, defcend immediately into the firft and fecond ftomachs in nearly the fame ftate as when firft browzed. Here they are foftened by the juices, as feeds are in the craws of birds with gizzards; but as the ftomachs of thefe quadrupeds have no triturating power, and the aliment requires trituration, it afcends, in confequence of a gentle ftimulus to vomit, into the cavity of the mouth, where by means of rumination, it is put into the fame ftate previous to being digefted by the gaftric fluid, as happens to the food in the ftomachs of granivorous fowls, after they have been properly triturated by the gaftric *mufcles.*

Animals with *intermediate* ftomachs, fuch as ravens, crows, herons, &c. have mufcular ftomachs, which are by no means equal in force to the ftomachs of the firft clafs, but much more fo than thofe of the third clafs. Thefe animals poffefs the privilege of returning fubftances they are incapable of digefting, at leaft every nine, and in general every two or three hours; they are omnivorous. Their gaftric juice does not diffolve whole

feeds, they therefore bruife them with their beak and feet, and they are diffolved in twenty-four hours; it foon diffolves flefh and cartilage, but not bone. The fluid in the œfophagus Spallanzani found inconfiderable as a menftruum, when compared with that of the ftomach, fince the firft was fix hours in diffolving two parts of flefh, and the fecond one hour only in diffolving fix parts; confequently the œfophagal liquor in the craws of the gallinaceous, is different from that in this clafs. The *refemblances* between the gaftric fluids of thefe two claffes may be reduced to five: firft, thefe fluids, befides being alike in colour, are always falt and bitter, which bitternefs proceeds from the bile regurgitating through the pylorus into the ftomach. Secondly, they are the immediate agents of digeftion, both in the mufcular and intermediate ftomachs, independently of trituration. Thirdly, the fluids act in the ftomachs of thefe two claffes of birds in the fame manner, in the folution of the food; they firft foften, and next convert the furface into a jelly, then produce the fame effect on the intermediate parts, infinuating themfelves gradually into it's fubftance until it is completely diffolved. Fourthly, they do not entirely lofe their folvent power as foon as taken out of the ftomach, provided they be heated to a proper degree. Fifthly, the origins whence thefe fluids fpring are nearly the fame, viz. the follicular glands with which their organs abound. With refpect to the *differences*, they are in part reducible to the inferior efficacy of the gaftric fluid in mufcular, to that of the fame fluid in intermediate ftomachs. The gaftric juice of the firft is incapable of diffolving the fame aliment that the latter readily diffolves. Likewife, the food which each kind of gaftric juice decompofes and digefts is fooner fubject to this change from that which belongs to intermediate ftomachs; hence, artificial digeftion fucceeds much fooner

with the firſt than the ſecond. The ſame inefficacy that the gaſtric juices of birds with muſcular ſtomachs ſhows in the ſolution of aliments of a firm texture, extends alſo to their œſophagal juices in the ſolution of ſoft ſubſtances; notwithſtanding the latter are tolerably well decompoſed by the œſophagal juice of birds with intermediate ſtomachs. Another very ſtriking difference, is the prodigious force of trituration in muſcular ſtomachs, and the weakneſs of the other, which greatneſs of ſtrength was neceſſary in birds, whoſe food is of conſiderable firmneſs, as ſeeds.

Animals with *membranous* ſtomachs, ſuch as frogs, newts, ſnakes, fiſh, ruminating animals, carnivorous birds and beaſts, as the eagle, falcon, man, dog, cat, &c. This claſs is infinitely more numerous than the two former. It comprehends nearly all the quadrupeds, fiſh, reptiles, birds of prey, and the greater part of inſects. From Spallanzani's experiments, it appears, that carnivorous birds do not diſſolve vegetables, and throw up the indigeſtible part every twenty-four hours; that nature in theſe animals, whoſe digeſtion depends on the gaſtric juice alone, without any previous maſtication or trituration, has provided them with a much larger quantity of it than the other claſſes; that digeſtion is in proportion to the quantity of this fluid; that the gaſtric juice of the ruminating claſs has no effect in diſſolving plants unleſs they have been previouſly macerated, and ground by the teeth; that it's colour in ſheep is green, and yellow in cows; that owls digeſt fleſh and bones, but not grain; that their gaſtric juice evaporates ſooner than water; that, that of the eagle diſſolves bread and bone; it's colour is cineritious, and it digeſts animal and vegetable matters out of the body; that a wood pigeon may be brought by degrees to live on fleſh; that the owl and falcon do not digeſt bread; that the gaſtric juice of the dog diſ-

ſolves the enamel of the teeth; and that trituration is neceſſary in the ruminating order, and man, which is produced by the teeth, as in gallinaceous fowls by the gizzard; but in other animals, as in the frog, newt, ſerpents, and birds of prey, trituration does not contribute to digeſtion.

Hence, in every order of animals, the gaſtric juice is the principal cauſe of digeſtion, and it agrees in all in many properties, and differs in others. In the frog, the newt, ſcaly fiſhes, and other cold animals, it produces digeſtion in a temperature nearly equal to that of the atmoſphere. In warm animals it is incapable of diſſolving the aliment in a degree of heat lower than that of theſe animals. In warm animals the food is digeſted in a few hours, whereas in the oppoſite kind it requires ſeveral days, and even weeks, particularly in ſerpents; likewiſe, the gaſtric juice of the gallinaceous claſs can only diſſolve bodies of a ſoft and yielding texture, and previouſly triturated; whilſt in others, as ſerpents, the heron, birds of prey, and the dog, it decompoſes ſubſtances of great tenacity, as ligaments and tendons; and even of conſiderable hardneſs, as the moſt compact bone. Man belongs to this claſs, but his gaſtric juice ſeems to have no action on the hardeſt kind of bones. Some ſpecies, likewiſe, are incapable of digeſting vegetables, as birds of prey; but man, the dog, cat, crows, &c. diſſolve the individuals of both kingdoms alike, and are omnivorous, and in general their gaſtric juices produce theſe effects out of the body.

Hence, the diſſolving power of this fluid depends on the difference of the nouriſhment, and by ſome authors it has been ſaid to be the cauſe of hunger and of the difference in the choice of the particular aliment, by which power the carnivorous only enjoy fleſh; the graminivo-

rous and ruminating, only vegetable aliments, and no fleſh; but man and the omnivorous, both vegetable and animal ſubſtances.

It is, however, aſſerted by Carradori as decided, that nocturnal birds of prey are capable of digeſting vegetables. It reſults from his experiments, that they alſo ſupport themſelves very well with this nouriſhment, in ſpite of their repugnance to it. If this be the caſe, the opinion is erroneous, that the gaſtric juice of theſe birds had only an affinity with animal ſubſtances; and what he has eſtabliſhed, viz. that carnivorous animals find a nutriment in the products of plants, was already rendered probable by the diſcovery of Fourcroy of the exiſtence of gluten, albumen, and gelatin in the vegetable tribes. Spallanzani, however, proves the inſufficiency of Carradori's experiments, as the owl died when confined to vegetable food.

The time requiſite for digeſtion is different in different animals. In many it does not exceed five or ſix hours, and in ſome it is much ſhorter.

From the numerous experiments of Goſſe of Geneva upon digeſtion, and the action which the gaſtric juice has upon different ſubſtances, great light has been afforded us upon this intereſting ſubject. Goſſe.

He informs us, that in about one hour and a half after the food is taken into the ſtomach, it is changed into a pultaceous maſs; the gaſtric juice, likewiſe, renders it fluid, without altering it's nature; and when digeſtion is properly carried on, there is no appearance of acidity or alcaleſcence; the food does not ferment; and the proceſs of digeſtion is not completed until the ſpace of between two and three hours has elapſed.

The chyme which ariſes from aliments taken either from the animal or vegetable kingdom is the ſame; they

both are, by the gaſtric fluid, converted into the ſame ſubſtance, which is in conſequence moſt probably of their both containing gelatin, &c. If, however, the digeſting ſolvent is not in ſufficient quantity, or is in a diſeaſed ſtate, the acetous fermentation will take place in vegetable, and the putrid in animal matter; hence milk, vegetable matter containing ſugar, wine, and even ſpirits will degenerate, when left to their ſpontaneous changes in the ſtomach, to a very ſtrong acid, and ſooner ſometimes than out of the body, perhaps from the heat, &c. All oily ſubſtances likewiſe become rancid, and fleſh meat putrid, producing acid and putrid eructations, which is never the caſe in a ſtate of healthy digeſtion; whilſt, in many animals the digeſtion is finiſhed before the acetous or putrid fermentation can begin.

Subſtances *inſoluble* or that were not digeſted in the uſual time in the ſtomach.

Animal ſubſtances.

1. Tendinous parts. 2. Bones. 3. Oily or fatty parts. 4. Indurated white of egg.

Vegetable ſubſtances.

1. Oily or emulſive ſeeds. 2. Expreſſed oils of different nuts and kernels. 3. Dried grapes, and the ſkins of fiſh. 4. Rind of farinaceous ſubſtances. 5. Pods of beans and peaſe. 6. Skins of ſtone fruits. 7. Huſks of fruits with grains or ſeeds. 8. Capſules of fruit with grains. 9. Ligneous ſtones of fruits. 10. It does not deſtroy the life of ſome ſeeds, hence bitterſweet, hemp, miſletoe, and other plants which ſometimes grow upon trees, are produced by the means of the excrements of birds, the kernels of the ſeeds being defended from the menſtruum by their exterior covering.

Subſtances *partly ſoluble*, or parts of which were digeſted.

Animal ſubſtances.

1. Pork dreſſed various ways. 2. Black puddings. 3. Fritters of eggs, fried eggs and bacon.

Vegetable ſubſtances.

1. Sallads of different kinds rendered more ſo when dreſſed. 2. White of cabbage, leſs ſoluble than red. 3. Beet, cardoons, onions, and leeks. 4. Roots of ſcurvy graſs, red and yellow carrots, ſuccory, are more inſoluble in the form of ſallad than any other way. 5. The pulp of fruit with ſeeds, when not fluid. 6. Warm bread and ſweet paſtry, from their producing acidity. 7. Freſh and dry figs. By frying all the ſubſtances in butter or oil they became ſtill leſs ſoluble. If they are not diſſolved in the ſtomach, they are, however, in the courſe of their paſſage through the inteſtines.

Subſtances *ſoluble* or eaſy of digeſtion, and which are reduced to a pulp in an hour, or an hour and half.

Animal ſubſtances.

1. Veal, lamb, and in general the fleſh of young animals, are ſooner diſſolved than that of old. 2. Freſh eggs. 3. Cows milk. 4. Perch boiled with a little ſalt and parſley. When fried or ſeaſoned with oil, wine, and white ſauce, it is not ſo ſoluble.

Vegetable ſubſtances.

1. Herbs, as ſpinach mixed with ſorrel, are leſs ſoluble. Celery. Tops of aſparagus, hops and the ornithogalus of the Pyrenees. 2. Bottom of artichokes. 3. Boiled pulp of fruits, ſeaſoned with ſugar. 4. Pulp or meal of farinaceous ſeeds. 5. Different ſorts of wheaten bread, without butter, the ſecond day after baking, the cruſt more ſo than the crumb. Salted bread of Geneva more ſo than that of Paris, without ſalt; brown bread in proportion as it contains more bran is leſs ſoluble. 6. Rapes, turnips, potatoes, parſnips, not too old. 7. Gum arabic,

but it's acid is ſoon felt. The Arabians uſe it as food.

Subſtances which *facilitated* the menſtrual power of the gaſtric juice, are ſea ſalt, ſpices, muſtard, ſcurvy graſs, horſe radiſh, radiſh, capers, wine, ſpirits in ſmall quantities, cheeſe, particularly when old, ſugar, various bitters.

Subſtances which *retarded* the gaſtric power are water, particularly hot and taken in large quantities. It occaſions the food to paſs into the inteſtines without being properly diſſolved. All acids, aſtringents, 24 grains of Peruvian bark, taken half an hour after dinner, ſtopped digeſtion. All unctuous ſubſtances, kermes, corroſive ſublimate. Goſſe likewiſe obſerved, that employment after a meal ſuſpended or retarded digeſtion, as well as leaning with the breaſt againſt a table, and that repoſe of mind, vertical poſition and gentle exerciſe facilitated it.

It likewiſe appears, that from the ſoluble power of this fluid, digeſtion goes on after death, but it is far leſs conſiderable than in the living animal; that in fiſhes it retains it's property of digeſting fleſh, but in an inferior degree to that of birds; and that in ſome animals, heat is neceſſary to this power which acts independent of the vital power.

Hunter attributes to the action of the gaſtric juice, the eroſions found in ſtomachs of thoſe who have died ſuddenly, in which, ſometimes, the great curvature of that organ is entirely conſumed; he often found them on opening dead bodies, the edges of the wounds appearing like half digeſted food. Spallanzani, however, although he agrees with Hunter that digeſtion may take place after death, is of opinion contrary to that celebrated anatomiſt, that heat is neceſſary.

Dr. George Fordyce.

The opinion of Dr. George Fordyce appears to reſem-

ble and ſupport thoſe of Spallanzani and Goſſe. According to this chemiſt, from the nature of the gaſtric juice and it's action upon different ſubſtances, when the ſtomach is in health, ſo as to ſecrete it in it's pure ſtate, the food is readily digeſted whilſt in weak ſtomachs; if the food be in too large a quantity, or does not readily enter into the digeſtive proceſs, or is a ſpecies which the ſtomach has not been accuſtomed to, the vegetable part will go into the acetous fermentation, and produce heartburn, vomiting, &c. and the animal into the putrid, whilſt the putrid matter, either by it's action upon the ſtomach, or it's introduction into the ſyſtem along with the chyle, he has known ſeveral times to produce a putrid and malignant fever.

He is of opinion that the ſubſtances taken into the ſtomach undergo ſuch a change as to become all the ſame ſubſtance, or as it has been called chyme, and that it is then rendered capable, but not before, of being converted into chyle. The properties, however, of chyme, are at preſent unknown. He thinks that this proceſs of the ſtomach is the moſt eſſential part of digeſtion.

The properties of the human chyle have not been inveſtigated, but according to Dr. Fordyce, as far as experiment has been carried, the chyle of quadrupeds, a claſs of animals in which man is to be ranked as far as he is not improved by culture, is ſo ſimilar as not to be diſtinguiſhed, not even in natural claſſes the moſt oppoſite to each other in their food, ſtructure, and habits of life. The chyle of a dog or of a wolf differs in nothing, as far as experiment has gone, from that of a ſheep or of an ox. Chyle.

The chyle conſiſts of three parts, one part which is fluid and contained in the lacteals, but coagulates on extravaſation.

The ſecond part conſiſts of a fluid, which is coagulable by heat, and in all it's properties hitherto obſerved, it is conſonant to the ſerum of the blood.

The third part conſiſts of globules, which render the whole white and opake. Theſe globules have been ſuppoſed by many to be an expreſſed oil, but this has not been proved. Neither has it been perfectly demonſtrated that ſugar is contained in the chyle, although it has been made very probable. The difficulty of determining theſe points is, the ſmall quantity that can be collected, the largeſt animals not ſupplying more than one ounce or two, at the moſt. However, the part coagulating on extravaſation; the part agreeing with ſerum in it's qualities; the globular part, which in ſome animals, but not in quadrupeds, exiſts without giving whiteneſs to the chyle, alone, or along with ſugar, form the eſſential parts of the chyle.

A great many ſubſtances may enter the lacteals along with the chyle; even ſolids reduced to a fine powder. When indigo has been thrown into the inteſtine of a ſheep, Dr. Fordyce has ſeen the chyle rendered quite blue; yet indigo is not ſoluble in water, but is a ſolid reduced to a very fine powder. Muſk likewiſe gets into the chyle, giving it a ſtrong ſmell, and a great variety of other ſubſtances of various colours, various taſtes, and various ſmells; each of them giving colour, or taſte, or ſmell to the chyle. The lacteals, however, reject ſome ſubſtances in whatever manner they are applied; amongſt theſe are green vitriol and infuſion of galls, for the chyle gives no colour when either is given with food to the animal, or thrown into the inteſtine, and it is afterward tried by them as teſts of each other.

According to Dr. Fordyce, the chyle is not formed in the ſtomach. Milk is that food which comes neareſt to

the chyle in it's external appearance, and as it is formed for the nourifhment of young animals whofe digeftive organs are weak, and neceffity for nourifhment great, it is obvious, that chyle is ready prepared, or nearly fo, in the veffels of the mother, to fave the powers of digeftion in the infant. Yet, on this entering the ftomach, there is a juice which coagulates it in a few minutes after, retards it in the ftomach, and retains it there for a confiderable length of time. The fame is produced on the white of egg, and ferum of the blood. This of itfelf would fufficiently prove that there is a procefs which it muft go through previous to it's being formed into chyle. It further appears, that food diffolved in water fo as to form a folution not capable of being coagulated and not detained in the ftomach, gives very little nourifhment in proportion to the fame quantity of the fame food given in a folid form, or a coagulable one. Hence a decompofition and recombination take place, but thefe do not appear to be the formation of chyle. Another circumftance is, that if it was chyle, the abforbents, which are numerous in the ftomach, would take it up as faft as it is produced, and would have the appearance of and actually be lacteals, and be perceived; but if a living animal be opened at any time during digeftion, there is no appearance of any chyle abforbed from the ftomach, and hence there is none to be abforbed. If we throw milk into a portion of the jejunum, it will be abforbed by the lacteals, but if thrown into the ftomach of the fame animal, the milk will not be abforbed by the lymphatics; hence it may be faid that the abforbents of the ftomach refufe what thofe of the jejunum readily take up; but the cafe is, that the milk is inftantly coagulated in the ftomach, and not in the jejunum, which coagulation will perfectly prevent it from being abforbed; but all thofe fubftances which are not changed by the coagulating juice of the ftomach are

equally taken up by the lymphatics in the ſtomach and lacteals.

It therefore appears that the uſe of the ſtomach is only to change the food into a new ſubſtance, the chyme, which is the only ſubſtance that can be converted into chyle. When this chyme is propelled into the duodenum, it is then converted into chyle, and not before; but the duodenum cannot have this action upon it, unleſs it has previouſly undergone the action of the ſtomach. There is nothing, therefore, in the whole doctrine of different ſpecies of food which can have any reſpect to any part of the body, excepting the ſtomach itſelf; for only thoſe parts of it that are converted into chyme will paſs into the duodenum and be converted into chyle; the other parts that have not undergone this change in the ſtomach will paſs through the duodenum unchanged, and be evacuated. So that according to Dr. Fordyce, it is perfectly immaterial what is the ſpecies of food, farinaceous matter, animal mucilage, apples, potatoes, wheat, muſhrooms or oyſters, beef, veal, chicken, ſalmon or gooſe. So long as it has undergone the proceſs of the ſtomach, and is converted into the matter formed by that proceſs, it gives equally good nouriſhment, and is equally innoxious, becauſe it becomes exactly the ſame. Sometimes a little whitiſh matter is ſeen about the pylorus, but this is not perfect chyle, for it is not ſeen in the abſorbents of the ſtomach, even although in the middle of digeſtion the pylorus be tied round by introducing a piece of tape, forming a ligature round it, and retaining the remaining food in the ſtomach. The matter, therefore, formed in the ſtomach, is converted into chyle in the duodenum, and continues to be converted in the jejunum.

As the coagulating juice of the ſtomach, as far as can be judged, does not enter into the matter or chyme form-

ed in the ſtomach from the food, nor the other juices of the ſtomach, only in ſo far as they ſupply water; ſo neither do the juices of the duodenum, the bile, pancreatic juice, or fluids ſecreted in the glands of thed uodenum, or which may paſs through the exhalants, at all appear to enter into any part of the chyle. For, according to Dr. Fordyce, if the ductus communis choledochus be obſtructed by a ſtone, or if the body of an animal be opened when food has been thrown into the ſtomach, and the duct be tied up, by which the bile is prevented from getting into the duodenum; in either caſe the chyle is formed without any particle of bile being admitted; and the ſame may be ſaid of the pancreatic juice; ſo that chyle is ſolely the product of the matter formed by the digeſtive proceſs of the ſtomach. The chyle is always the ſame, but not always in the ſame proportion to the quantity of food. Scarcely any digeſtible matter is ever found in the duodenum, in the form it was thrown into the ſtomach; hence all of it ſeems to undergo ſome change or other.

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BILE.

THIS is a yellowifh green fluid, which is feparated from the blood by means of the liver, a vifcus occupying a very large fpace in the animal body. In man, and in the generality of quadrupeds, birds, &c. there is a refervoir attached to this organ, which contains this fluid in more or lefs quantity; in man, it has been computed at an ounce on an average; but in the elephant, ftag, and in all infects and worms, this refervoir is wanting. Bile.

The bile in man, and in quadrupeds, &c. is not only collected in the gall bladder, from whence it is conveyed by the cyftic duct, but another portion of bile is brought directly from the liver itfelf, and flowing into the hepatic duct, joins the cyftic by the name of the ductus choledochus communis, and enters the duodenum; hence the bile may be divided into the hepatic and cyftic.

1. The *hepatic bile* has not as yet undergone any chemical inveftigation; it is, however, faid to be milder in it's tafte, lefs highly coloured, and thinner in confiftence than the cyftic. Two kinds.

2. The *cyftic bile*, when pure and in a healthy ftate, is of a green colour, inclining to a yellow; this, however, appears to depend on the quantity of aqueous fluid it contains; for when diluted, this yellow tinge is very confpicuous; and when in a more concentrated ftate, it is of a deep green. In the greater number of quadrupeds, and in man, it is of a yellowifh green, but in birds, oviparous animals and fifh, it is conftantly green; it is likewife faid to be much darker in carnivorous than in grami- Cyftic bile. It's properties.

nivorous animals. In diſeaſes it is of all ſhades, from a pallid hue to a direct black; thus in cachexy and dropſy it is very pale; whilſt in melancholia, yellow fever, and plague, it approaches more or leſs to a black. There are inſtances of it's being affected by aliments, and of it's being tinged by the uſe of different vegetables.

It's ſavour is very bitter, accompanied with a certain degree of pungency; if, however, aloes be mixed with it, the production is ſaid to be a ſweetiſh taſte. This natural ſavour is ſtronger in the bile of carnivorous than of herbivorous animals, and in oviparous quadrupeds it is ſaid to be exceedingly pungent, but not very bitter; and the ſame is the caſe with that of fiſh; whilſt examples are recorded of this fluid becoming ſomewhat acetous to the taſte.

In conſiſtence, it is viſcous and tenacious, reſembling a ſirup or oil, and when agitated in a phial it foams like ſoap water. On it's firſt flowing into the gall bladder, it is more aqueous than after it has reſided there ſome time, and at times it is found in part coagulated. This tenacity in the bile Dr. Saunders ſeems inclined to explain, from it's being a compound fluid, conſiſting in part of genuine bile, with a portion of the mucus ſecreted by the gall bladder.

The conſiſtence, taſte, and colour, however, are properties of this fluid which appear to depend on the ſame cauſe, for the more aqueous it is, the more light coloured and leſs bitter; on the contrary, if it's viſcidity be increaſed, it's ſavour and colour are of conſequence increaſed in ſtrength; and it is found to be more viſcid, more bitter, and deeper coloured in the gall bladder than as it flows from the liver, from the aqueous parts being taken up by the abſorbents. In adult animals in health, it is likewiſe more viſcid, deeper coloured, and more bitter than in younger ones, whilſt in the fœtus, it is ſaid to be

ſweetiſh, very aqueous and of a reddiſh hue. It is likewiſe more viſcous in man than in quadrupeds.

In diſeaſes theſe differences are more evident.

It's odour is diſguſting and nauſeous, but in ſome animals, when freſh, it is ſaid to poſſeſs an agreeable ſmell ſimilar to that of muſk; whilſt in others, this muſky ſmell may be obtained by evaporation, or they obtain it ſpontaneouſly by putrefaction.

It is ſpecifically heavier than diſtilled water, but it differs greatly in this reſpect; according to Muſchenbrœck, the proportion is as 1,0246 to 1,0000.

Diluted with a little water, it changes the ſirup of violets green.

It is perfectly ſoluble in water, and affords a clear ſolution of a more or leſs yellow colour, according to the quantity of menſtruum.

All the acids on being added to this fluid, decompoſe it in the manner of ſoaps and alſo produce a coagulation of the albumen. If the mixture be filtrated, and the liquor evaporated, a neutral ſalt is obtained, compoſed of the acid employed and ſoda. This beautiful experiment is due to Cadet, and ſhows the preſence of ſoda in the bile. According to Fourcroy, the matter left on the filter is thick and viſcous, and compoſed of two different ſubſtances; the one is the coagulated albumen, the other a bitter and very inflammable matter, varying in colour and conſiſtence according to the degree of concentration of the acid employed to ſeparate it.

The preſence of ſoda in bile.

Albumen and reſin.

Theſe acids affect the colour of the bile; thus, by the ſulphuric, a deep green is produced; the nitric, when a little concentrated, gives it a brilliant yellow, and the muriatic a very beautiful clear green. Theſe colours, however, vary according to the ſtate of the bile and the acids. If bile be previouſly diluted with water before the addition of the acids, we are informed by Hildebrandt

Acids affect it's colour.

that the part which is not coagulated remains diſſolved in the water. The precipitate above mentioned has been looked upon, particularly by Van Bochante, a chemiſt of Bruſſels, (in a diſſertation on the colouring matter of the bile,) as a ſubſtance analogous to the reſins. On being placed upon red hot coals, it ſwells, melts, and inflames; it is totally diſſolved by alcohol, and precipitated again by water, like the reſinous juices. According to Fourcroy, the action of the acids ſhows, that the bile is a real ſoap formed of an oil analogous to the reſins; united to ſoda, they likewiſe announce the preſence of a certain quantity of albuminous matter in this animal liquor, which is the cauſe of it's being coagulated by them, as well as by heat and alcohol, as will ſoon appear. It is likewiſe this part of the bile that undergoes the putrid fermentation.

The action of acids proves the bile to be a real ſoap.

According to the ſame chemiſt, the oxygenated muriatic acid deſtroys the colour of bile, and coagulates it's albumen, which is precipitated in the ſtate of white flocks; the biliary ſoap remains in ſolution, which in appearance is nothing but pure water, having loſt it's colour and odour, and only preſerving all it's bitterneſs. If more of the acid has been added than is ſufficient to coagulate the albumen, the exceſs acts by degrees upon the oil of the ſoap, and returning again to ordinary muriatic acid, decompoſes a part of the ſoap and ſeparates it's oil in a concrete form, and of a white colour. Since it appears, that it is only by furniſhing the albumen with oxygen, that the oxygenated muriatic acid coagulates the bile; this chemiſt thinks it probable, that the portion of this acid returned to it's ſimple ſtate decompoſes a certain quantity of the biliary ſoap, and conſequently, the albumen is always mixed with a little of the reſin or the concrete oil of the bile.

The colour deſtroyed by oxygenated muriatic acid.

If a ſimple acid, as the ſulphuric or muriatic, &c. be

added to the bile, after it is become colourlefs by the oxygenated muriatic acid, a white concrete precipitate is immediately formed of the confiftence of fat. This precipitate, which is the oil of the bile fomewhat changed by the oxygen of the muriatic acid, perfectly mixes with water, and is even diffolved by the aid of heat. This property is the more fingular, fince the foda which renders it foluble is no longer prefent; having united to the acid ufed in the decompofition of the bile.

A white concrete oil found on adding a a fimple acid to the colourlefs folution

This *white concrete oil* is foluble in the cold, in alcohol; and if the folution be accelerated by heat, a certain quantity of æther is formed, which appears to arife from the oxygen contained in the oil uniting with the alcohol, and changing the proportion of it's principles. The alcoholic folution expofed to the air lofes it's alcohol by degrees; but it is with great difficulty that it becomes folid. If, when it is about the confiftence of a firup, it be mixed with water, it unites perfectly with it, which feems to announce, that the biliary foap has not been decompofed; but when an acid is added to this folution, a precipitation is immediately the confequence. Another experiment not lefs fingular is, that if a frefh quantity of alcohol be put to the folution of the oil of the bile, thus infpiffated by the air and water, and afterwards added, an abundant precipitate takes place.

Properties of the white oil.

It appears, that the fame phenomenon of the folubility in water of this bilious oily matter, which was pretended to be a refin, had been previoufly obferved before in the laboratory of this chemift; but it would feem, that this pretended refin, which is precipitated by an acid, is in part foluble in water, and only takes an apparent character of infolubility in this fluid, from the prefence of an acid.

It was conjectured, that this white concrete oil had fome analogy to the white and cryftalline matter of the

Differs from the cryftalline matter

of biliary calculi. human biliary calculi; but it was soon evident that it differs from it in several properties.

1st. It is more soluble in alcohol, and is not precipitated in small lamellæ.

2d. It is soluble in water.

3d. It is of much softer consistence and more fusible, being nearly equal to the fusibility of fat (at 32° or 33°), whilst the crystalline matter of the human biliary calculi only melts at a heat above 90°, and remains solid at a few degrees above boiling water.

Action of salts upon bile. The neutral alkaline salts mixed with bile prevent its putrefaction; the ammoniacal salts are decomposed by it; the earthy neutral salts are decomposed, and precipitate it.

Metallic salts decompose it, and are decomposed at the same time by it; the soda of the bile unites to the acid of the solution, and the coloured oil of bile is precipitated in union with the metallic oxyd.

Unites with oils. Bile unites readily with oils, and like soaps takes out any greasy spots from cloth; hence the bile of the ox is used in cleansing stuffs.

Bile a real animal soap. The bile, or biliary soap as it may be properly called, is soluble in alcohol, which separates it's albumen in a coagulated state. This tincture of bile is not decomposed by water, which shows the substance to be a real animal soap, equally soluble in water and in alcohol.

It is likewise easily dissolved by æther.

Putrefies sooner than blood. Dr. Saunders, in order to try whether the bile had a greater power of resisting putrefaction than the blood, put equal quantities of blood and bile of the same ox into different vessels of the same size, and exposed them to the same degree of heat, and found that on the third day the blood began to show signs of putrefaction, whilst the bile remained in it's natural state; on the fourth day the bile had a pungent odour by no means ungrateful,

whilſt the blood was extremely putrid. On the 6th day the bile became putrid, and had a very offenſive ſmell. The progreſs of putrefaction in bile is, according to obſervation, as follows:

Expoſed to the air, at a warm temperature of from 15° to 25°, a change very ſoon takes place; it's aroma becomes at firſt nauſeating; it's colour changes; whitiſh mucilaginous flocks are precipitated; it loſes it's viſcoſity, and ſoon becomes fœtid and ſtrong to the organs of ſmell. When the putrefactive proceſs is far advanced, it's odour becomes mild and ſomewhat reſembling ambergris. It has been obſerved by Vauquelin, that after inſpiſſating ſomewhat bile in the baln. mar. it keeps ſeveral months without change, as is the caſe with vinegar when boiled. He found that the bile of the ox, which exhaled a fœtid odour, was of a dirty brown colour, and turbid; became on being heated of a beautiful green; loſt it's odour whilſt ſome albuminous concrete flocks were ſeparated, and that it is no longer ſo ſubject to change as when it is in it's natural ſtate. When ſubmitted to diſtillation, there ariſes a phlegm which ſhews no traces either of an acid or an alkali; after a certain time it becomes putrid. This phlegm has often preſented to Fourcroy a well marked, mild, aromatic odour, very analogous to that of ambergris or muſk. The obtaining this aroma particularly ſucceeds, if the bile be diſtilled after it has been kept a few days, and is a little changed. The ſame is the caſe with bile, after having being ſomewhat inſpiſſated, and kept a long time.

Action of heat upon bile.

It's muſky odour.

When bile has been inſpiſſated, by a ſufficient expoſure to heat, to a more or leſs dry extract, it is of a deep green or brown colour, very tenacious, and of a pitchy conſiſtency; it deliqueſces, and is nearly wholly ſoluble in water. On being diſtilled the inſpiſſated bile affords a yellowiſh alkaline phlegm, an empyreumatic oil, a

Products of inſpiſſated bile on diſtillation.

large quantity of carbonet of ammonia, an elaſtic fluid mixed with carbonic acid, carbonated by hydrogenous and azot gases. The remaining coal is found in large quantity, and, according to Macquer, very ſaline; it is leſs difficult of incineration than that of moſt other animal ſubſtances. According to Cadet, who preſented to the academy, in 1767, an excellent memoir on the analyſis of the bile, this coal contains carbonat of ſoda; an animal earth, *i. e.* phoſphat of lime, and a ſmall quantity of oxyd of iron. If the bile be diſtilled on the open fire, great caution is neceſſary from it's ſwelling conſiderably. When heated to 60° it coagulates, and becomes a flocky, thready maſs, which ariſes from it's albumen. Fourcroy has likewiſe obſerved in the products of the bile, after diſtillation, in the retort, and rectification, a ſmall portion of pruſſic acid, partly free and in part combined with ammonia.

When bile has loſt it's oil by expoſure to a ſtrong heat, it's carbon is difficult to incinerate; for we are informed by Fourcroy, that whilſt it is undergoing a red heat, the ſoda ſo eaſily volatilizes, that the aſhes being ſtill blackiſh, no longer contain any alkali, and ſhow no traces of it in water. Incineration appears, therefore, a defective proceſs to arrive at the fixed parts of bile, and more eſpecially to determine their proportion.

Component parts of bile.

On collecting the component parts of the bile, it is found to contain a large portion of water; a peculiar concreſcible oil united with ſoda, forming a ſaponaceous ſubſtance; and an albuminous mucilage which is coagulable. Several other ſubſtances, beſides it's aroma and colouring matter, are ſaid to contribute to it's formation. Thus, Cadet, independent of the phoſphat of lime, thinks he found a ſalt in the coal of the bile, of the nature of ſugar of milk, the exiſtence of which Van Bochante has ſince confirmed; but Fourcroy is of opinion, that this

pretended saline matter is rather to be looked upon as analogous to the oily, leafy, brilliant and crystalline substance that Poulleter found in the human biliary calculus, and Hildebrandt is of opinion, that the substance which communicates a bitter savour to the organs of taste forms an essential part of it; since it appears from the experiments of Leonhardi and Richter, that bile, even when reduced to a coal, still retained it's bitterness. Common salt and iron have likewise been said to be found in it; but according to other chemists, these are only accidental.

Opinion of Hildebrandt on it's bitter taste.

The last chemist who has paid any attention to the component parts of bile is Dr. Saunders. This physician, from various experiments, concludes, that it consists, 1. Of water impregnated with the odorous principle. 2. A mucilaginous substance, resembling the *albumen*. 3. A resinous substance containing the colouring principle and bitter taste, and 4. The mild mineral alkali. With respect to their combinations he is of opinion, that the saponaceous matter consists of the bitter resin in union with the alkali; that this admits of a ready union with a mucilage, and with this again the aqueous matter.

It's component parts according to Saunders.

Homberg, Bourgelat, Cartheusar, and Ramsay, have made a few experiments on it with acids and a few saline bodies, but they have contributed nothing towards the discovery of it's component parts; and, perhaps, little was done respecting it's analysis, till Cadet, by a course of well directed experiments, threw more light upon it than all his predecessors had done before him. He is said to be the first who actually discovered the presence of soda in it, although Roeder had shown the existence of it much about the same time. This fluid had, indeed, been long made use of in the cleansing of greasy and oily spots from cloth, from it's having been found to possess saponaceous properties; but independent of this,

ſeveral phyſicians, ſuch as Burggrave, Hartmann, Baglivi, and Verheyen, had made ſome few experiments upon it, by which the preſence of an alkali had been detected. It was likewiſe known, that by the addition of acids the gall became turbid, and that on mixing them with a ſolution of ſoap, they equally brought about the ſolution of an oily matter. At length the work of Gardani appeared, from whoſe experiments, made with great care and diligence, it was proved, that this fluid had the power of precipitating ſalts with a metallic baſis. All theſe facts ſufficiently ſhow the preſence of an alkaline ſalt, and agree very well reſpecting it's ſaponaceous property; but there remained to diſcover the nature of the alkali, which was effected by Cadet, in an excellent treatiſe on the bile, read before the Academy of Sciences, and printed in the year 1767. He found that on treating bile with the muriatic acid, he obtained by cryſtallization common ſalt; with the nitrous acid, it gave the nitrat of ſoda; and with vinegar, a cryſtallized neutral ſalt compoſed of ſoda and the acid employed; which experiments clearly convinced him, that the gall contained an alkali, and that this alkali was the ſame as that which aſſiſted in the compoſition of common ſalt or ſoda; and having afterward found the ſame alkali in the aſhes after incineration, every doubt was cleared up of it's nature.

Cadet. Cadet likewiſe found, that the mineral acids at firſt produced a coagulation of the bile; but afterward diſſolved and brought it to a ſtate of greater fluidity; he confirmed the preſence of calcareous earth in it by the formation of ſelenite on the addition of the vitriolic acid; ſhowed, that the aqueous part of the bile contained a ſalt reſembling the ſugar of milk, and that it likewiſe poſſeſſed amongſt it's component parts an animal fat, common ſalt, and a little iron.

Rœderer. Rœderer, who, as before obſerved, had been engaged in

making experiments much about the ſame time as Cadet, or a little before, in 1767, coincided in great meaſure in the reſults. He found, that on mixing the three mineral acids with gall, he obtained from the fluid which covered the gummy reſinous precipitate that fell down cryſtals of Glauber's ſalt, of cubic nitre, and of common ſalt; a clear proof of the preſence of mineral alkali in this animal fluid. He thought, however, that this alkali appeared to be in part ſaturated with muriatic acid; for the coal of the bile, beſides ſome oblong cryſtals that effervefced in the air, (but which ought not to have been taken for Glauber's ſalt without further proof, being certainly mineral alkali,) afforded him likewiſe cubic cryſtals that decrepitated in the fire. He, likewiſe, as well as Cadet, found the preſence of calcareous earth in bile from the production of ſelenite with vitriolic acid; but the exiſtence of iron had eſcaped his notice; he however thought he had found an acid in it, and that it had the power of coagulating milk; but Cadet proved the contrary, and conjectured that the acid, if it exiſted, might have ariſen from the gelatinous part of the bile.

With reſpect to the ſaponaceous nature of this fluid, opinions have been different, ſome contending for the affirmative, others aſſerting the negative. The idea of it's being a ſoap originated from it's cleanſing property; but this is only one of the properties which a real ſoap poſſeſſes; hence, other experiments were neceſſary to arrive at the truth. Geſner was not able to diſſolve ſuet either with the aqueous ſolution of dried gall, which had been kept a year, or with freſh ox bile. Schroeder was likewiſe unable to bring about a ſolution either of the reſinous or oily ſubſtances in bile. Rœderer found, by experiment, that the fat oils united better with bile than with ſoap, but that their union with the laſt was more

Different opinions of it's ſaponaceous nature.

durable; that bile did not entirely refuse to unite with ethereal oils; but that, old oil of turpentine excepted, it was not able to bring them to any solubility in water, and that it showed not the least solvent power upon the resins. It was in consequence of these experiments and others, which several chemists had given to the world, to prove that bile cannot be mixed either with ethereal or fat oils or butter, or render those bodies soluble in water, that some chemists affirmed, more particularly Schroeder, Goldwitz, and Jacquin, that bile ought not to be considered as a soap; and the last has concluded, that if it be employed with success for removing spots out of cloth, the reason is, that the bile has a greater affinity with the cloth than the fat oils, which are consequently disengaged and issue in drops. Leonhardi is, however, of opinion, that as it appears from decomposition, that bile contains volatile as well as fixed alkali, with oily parts in it's composition, and that since it can unite fat oils with water, although the union is not so lasting as when soap is used, the saponaceous character cannot be entirely denied it. Robert had affirmed, in a dissertation, entitled, An bilis sapo acido-alcalinus, Paris, 1759, that there was a double soap in bile, an alkaline and an acid one; but he could not support his assertion by any chemical experiment. Macquer concluded, that it possesses a peculiar property approaching to a real soap, consisting of fixed mineral alkali, and such a quantity of oil as is necessary to give rise to such a saponaceous mixture as bile is allowed to have. At last, Fourcroy, as before mentioned, added greater light by his experiments on this subject, and proved, that it is an oily and saponaceous substance, composed of an oil nearly approaching to the state of spermaceti, together with a quantity of liquid albumen.

With respect to the component parts of bile, Durande

and Willink had attefted the prefence of iron in it; but neither Maclurg, by means of galls, nor the experiments of Leonhardi were able to detect it; and the latter is of opinion, that it is only accidentally met with in this fluid. Goldwitz endeavoured to prove that oil, air, alkali, and iron were not contained in it; that the lacto-faccharine fpecies of falt was only accidentally prefent in ox gall, and only then in the fpring; and that it's component parts, befides coagulable lymph, confift of a liquid peculiar to it formed of water, phlogifton, and a very fmall quantity of earth. That bile contained no alkali this chemift concluded, becaufe it did not effervefce with acids, which every alkali ought to do; and Stræhl, who publifhed a book at Gottingen, de Bilis Natura, in 1787, fupported Goldwitz in his opinion. On the contrary, Richter undertook the defence of the exiftence of an alkali in bile. He found, that the experiments of Cadet and Rœderer were entitled to every claim of veracity; for each of the mineral acids, after being added to this fluid, formed a coagulated and more or lefs green or yellow coloured precipitate; and the fluid above it, on evaporation, afforded a neutral falt, of the fame nature as that which the mineral alkali forms with the fame acids. With vinegar an arborefcent cryftallization arofe, which, however, he would not affirm to be acetated foda; he likewife obtained common falt by means of diffolving the extract in alcohol. Having incinerated the coal from bile, and made a ley of it, he got by the addition of vitriolic acid Glauber's falt by evaporation, whilft a portion to which no acid had been added afforded mineral alkali; he alfo, on incineration, obferved a fmell of garlic, which called to mind the prefence of Prouft's falt, or the mineral alkali united to phofphoric acid. Leonhardi is of opinion, that the alkali certainly exifts in bile, either in a free ftate or imperfectly faturated

Opinions of it's conftituent parts.

with the phofphoric acid; for in his experiment with the frefh bile of the pig, which, according to Delius, approaches the neareft to the human, litmus paper became much darker, and turmeric paper of a brownifh red. With refpect to common falt, it appears from the fupplement to Richter's Memoir, by Delius, that it's prefence was detected in human bile by the microfcope, in the form of cubic cryftals, as well as the prefence of an ammoniacal falt of a cruciform fhape. Leonhardi thinks, that the volatile alkali obtained in the diftillation of bile is certainly united with an acid. Richter obtained an oil from bile, but in very fmall quantity, by diftillation; and Prieftley fhowed the prefence of phlogifton on treating the extract with nitrous acid, and producing nitrous gas; whilft other animal fubftances treated in the fame manner only afforded phlogifticated air. Gren believed there was a refin in it from the folubility of a part of the extract in alcohol, and that this bitter refinous part was united with water, lymph, alkali, and gelatin, the remaining component parts. The bitter part appears to Leonhardi to be fixed, fince the coal, both in his experiments and in thofe of Richter, was found to have a bitter favour. He thinks it not improbable, but that this bitter matter may confift of the faccharine acid, deprived in part of it's fixed air, and united in different proportions with oily or inflammable parts; which acid, according to Berthollet, is found in animal as well as in vegetable bodies. Flour fpoiled by moifture, rotten apples, and rancid fat oils, all have a bitter tafte. Thefe contain acid of fugar and lofe fixed air. Bile appears to this chemift, by it's bitternefs, to oppofe and prevent the extrication of fixed air, fo that the fat parts of the chyle do not become rancid, the gelatinous parts putrid, nor the mucilaginous parts, capable of the vinous fermentation, four; befides, according to the experiment of Milman, bile impregnated

with fixed air is longer in becoming putrid than without it. From this ſhort and general hiſtory of the experiments upon bile, it appears, that it is to Cadet and Rœderer we are indebted for the diſcovery of the preſence of ſoda in that fluid, which is acknowledged to exiſt in a diſengaged ſtate; and to Fourcroy for the knowledge of it's other component parts.

USE OF THE BILE.

Various opinions on the uſe of the bile.

THE grand object of chemiſtry in the analyſis of animal ſubſtances is to aſſiſt the phyſiologiſt in diſcovering the nature and utility of the matter ſubjected to his inveſtigation, and to endeavour not only to account for it's formation, but to lay before the phyſician the means which may be employed to protect or abſolve it from the action of diſeaſe. The variety of opinions which have been given on the uſe of the bile, is a great proof of the obſcurity in which this function is enveloped; and ſhould the concluſion, that has been drawn from the analyſis of this fluid, not be rendered perfectly ſatisfactory, it is at leaſt to be hoped, that it may ſtimulate the ſcientific chemiſt and phyſiologiſt to redouble his efforts on ſo curious and intereſting a ſubject of inquiry.

The conſtancy of the bile in every animal, even in inſects and worms; the ſize of the viſcus that prepares it, and the deſtructive and grievous conſequences ariſing from it's diſeaſes, are very convincing proofs of the important part it acts in the animal economy. The great purpoſe to which this fluid is deſtined, according to phyſiologiſts, and more particularly thoſe of the preſent time, is that of aſſiſting the proceſs of digeſtion; and Fourcroy, to whom we are indebted for ſo many experi-

ments on the ſubject, is of opinion, that to promote and facilitate the digeſtive proceſs, is one of it's uſes. He thinks, that it's ſoapy quality renders it capable of uniting the oily parts of the alimentary matter to water; that it's bitter ſavour indicates it's being a ſtimulus to the inteſtines; and that it favours their action upon the aliments. It appears to him, that it is decompoſed in the duodenum by the acids which exiſt, or which are almoſt always forming in the organs of digeſtion; and that at leaſt it is certain it is very much changed, particularly in it's colour, when it becomes a portion of the excrements to which it communicates the yellow hue.

Some of the ancients as well as moderns, looked upon it in a very different light. Galen. Galen and Paracelſus were of opinion, that it was nothing but an excrement; Roux, that it's principal office was to evacuate the colouring part of the blood from the body; Liſter. and Liſter affirms that it is of no uſe whatever.

With reſpect to it's uſe in digeſtion, if the formation of chyle be the object, Dr. G. Fordyce has proved, that if the ductus communis choledochus be obſtructed by a ſtone, or tied up artificially in animals, it does not prevent the formation of chyle; hence the bile can be of no uſe in that proceſs.

Fourcroy. Fourcroy ſeems to think, that it is deſtined for another purpoſe beſides digeſtion. He is of opinion, that the blood, as it circulates through the meſenteric, ſplenetic, and hepatic arteries, and afterward into the diviſions of the vena portarum, undergoes great changes in it's nature; whether, as phyſiologiſts ſay, it diſſolves and takes with it ſome of the fat of the inferior abdominal region, which is ſcarcely poſſible; or rather, on traverſing theſe different regions very gradually, the carbon it contains unites with the oxygen, which, as it were, has only been interpoſed between the molecules of it's compo-

nent parts during refpiration in paffing through the lungs; and confequently being a long time in regaining that vifcus, it affumes a fat character from the fuperabundance of hydrogen which it communicates to the organs it nourifhes and fupports. If this be the effect in man and in quadrupeds, whofe refpiration is fo perfect, in the veffels through which the blood circulates with rapidity, it ought to be infinitely more marked in thofe animals who are able to live a long time in the mud or moft infectious filth without breathing, and when refpiration does take place, is only in a very limited and imperfect manner, from the fmallnefs of their refpiratory organs, and the confequent admiffion of a very fmall quantity of air; which air cannot be intimately united with the humours for a long time after it's reception, from the flownefs with which they circulate. Hence thefe amphibious animals are more or lefs foft and cartilaginous, pale, and even colourlefs throughout their compofition; have very little fenfibility, and are without agility. This chemift has drawn thefe conclufions from the component parts of the bile, from finding traces of oil fometimes on tearing or cutting the human liver, and that of quadrupeds; from the liver of the ray containing more than half it's weight of oil perfectly formed; from certain parts of the lower belly in difeafes of the liver taking a fat character, and becoming white or rather gray like the liver of the ray; from the livers of flying animals, particularly of birds expofed to a high temperature, and fed on milk, taking the fame character; and from the fize of this vifcus in amphibious animals when compared to others, and the liquidity and oilinefs of their brain, which may be attributed to a very limited refpiration.

Dr. Saunders looks upon the particular office of the bile to be a ftimulus to the inteftines, keeping up their Saunders.

energy and periſtaltic motion. It is alſo ſaid, that by virtue of it's alkaline nature it corrects acidity, reſiſts fermentation, and in conſequence of it's bitter quality, retards the putrefactive proceſs.

Is not the bile merely an excrement?

If I may be permitted to hazard a conjecture upon the uſe of the bile, and the viſcus that ſecretes it, it would appear, as Fourcroy has well obſerved, that the liver has a great connection with the lungs, not only from the facts already mentioned, but from the large ſize of this viſcus in the fœtus which has not yet reſpired; and that whatever action the bile may have upon the food, or on the inteſtines in digeſtion, there is reaſon to believe that the liver deprives the blood which paſſes through it of ſome of it's noxious parts, performing an excrementitious operation in the abdomen, whilſt the lungs are acting to the ſame end in the thorax. This appears probable, not only from the large ſize of the liver in thoſe animals of limited reſpiration, but even the extent of this viſcus in man and quadrupeds, which is by far the moſt voluminous gland in the body, indicates, that it's action muſt be of greater extent than that of furniſhing a mere ſecretion. All the glands form their ſecretions from the blood in it's moſt perfect ſtate, or as it circulates through the arteries; whilſt on the contrary, the liver makes uſe of the impure venous blood, ſupplied by the vena porta; which blood has been ſaid by ſome, although denied by others, to be in a ſtate of greater fluidity, and to have a putreſcent tendency, ſo as ſcarcely or not at all to be coagulated; or in other words, poſſeſſing a ſuperabundance of ſoda, which preſerves it's fluidity, and of carbon and hydrogen, which give it a dark colour. If this be the caſe, it is probable, that as this blood circulates through the liver, this viſcus deprives it of the hydrogen and carbon, which, united to a little oxygen, form an oily matter,

and meeting with the ſoda, a ſaponaceous ſubſtance is produced, which forms the principal character of the bile. Hence ariſes the neceſſity of this fluid being made with conſtancy and regularity, for the integrity of all the functions; and the reaſon of it's exiſting in all animals, and of it's being as neceſſary as the evacuation of the lungs during reſpiration. In thoſe animals whoſe reſpiratory organs are very ſmall in compariſon to their body, and where the carbon and hydrogen muſt be in large quantity in their blood from the want of proper evacuation, the liver is remarkably capacious and great in proportion, by which means theſe ſubſtances are evacuated in the form of bile, the act of reſpiration being inconvenient to their mode of life. It is by ſuch means that theſe two viſcera aſſiſt each other, (vide animal oils). To this opinion of it's being an excrementitious matter, may be added ſeveral other properties of a like nature, viz. it's nauſeous and diſguſting ſmell and taſte.

It appears, from the experiments of Fourcroy, that the oily part of the bile is nearly in the ſtate of ſpermaceti, preſerving it's fluidity during a ſtate of health. When, however, this matter is too abundant to remain in ſolution in the bile, it becomes cryſtallized, forming the calculi of the gall bladder, or gall ſtones, which, on analyſis, evidently appear to owe their formation to this oily concreſcible matter; and this matter being contained either in the pores or parenchymatous ſubſtance of the liver, often proves the ſource of ſeveral of it's diſeaſes.

To conclude, whatever may be the functions of the liver, and the uſe of the bile, many experiments are neceſſary before any real proof can be had that is perfectly ſatisfactory; and as much may be brought againſt every opinion which authors have yet given, it follows

that the liver fulfills an operation, the whole of which ſcience has not embraced.

Haller's Element. Phyſiol.—Encyclop. méthod. tom. 2. chimie. p. 564.—Cadet, Experiences chimiques ſur la bile des hommes & des animaux, in the Mém. de l'Acad. de Paris, 1764; alſo his Nouvelles Récherches pour ſervir à déterminer la nature de la bile, ibid. 1769.—Jo. Mich. Roederer, Experimenta circa bilis naturam. Argent. 1767.—Schrœder, Experimenta ad veriorem cyſticæ bilis indolem de clar. capt. ſect. 1. Gotting. 1764.—Sebaſtian Goldwitz neue Verſuche zu einer wahren phyſiologie der Galle. Bamberg, 1785.—Guil. Mich. Richteri experimenta & cogitata circa bilis naturam, imprimis ejus principium ſalinum. Acc. Henric. Frid. Delii de bile humana Epiſtola. Erlang. 1788.—Jacquin's Elements, —Macquers Wœrterbuch von Leonhardi, article Gall. —A Treatiſe on the Structure, Œconomy, and Diſeaſes of the Liver, &c. by Wm. Saunders, M. D. F. R. S. &c. London. 1795.—2d edit.

SALIVA.

THIS, when frefh and in a healthy ftate, is a tranfparent colourlefs liquor, without aroma or favour, and is fecreted into the mouth of an animal to affift in the maftication of it's food. It's properties.

It's fpecific gravity, according to Haller, is to water as 1960 to 1875.

In carnivorous animals, it is faid to be fomewhat acid, and manifeftly faline; and in the human fubject, in difeafe, from having no favour becomes bitter, fharp, fweet, four, putrid, or faline, and fometimes it is faid to partake of feveral of thefe favours at the fame time.

In confiftence, it is fomewhat lefs fluid than water, but more fo than mucus; it does not freeze fo foon as water, and when mixed with air, is converted into froth.

It is imperfectly foluble in water.

It mixes imperfectly with oils to a milky fluid.

It has no action on the tincture of litmus or fyrup of violets.

Alcohol in fome meafure coagulates it.

Acids in fmall quantity produce a flocky appearance, in large quantity they diffolve it.

According to Plenck, cauftic alkalis and lime extricate ammonia from it.

From Pringle's experiments, it poffeffes a feptic quality.

In a warm atmofphere it foon runs into the putrid fermentation.

It appears to have a flight action on fome of the metals, as iron and copper. Acts upon iron and copper.

It's component parts.

It's component parts appear to be four-fifths of water, albumen, according to Plenck ammonia, and an animal earth, which, according to Weber, contains muriat of ſoda, to which he has added calcareous earth.

Brugnatelli found the ſaccharine acid in the ſaliva of a venereal patient, whoſe diſeaſe was of long ſtanding.

Boerhaave ſays, it promotes the vinous fermentation, on which account the Indian women are accuſtomed to chew the maize before they mix it with water, to promote it's fermentation; it is then uſed as an agreeable drink.

Helvetius the alchemiſt expected to find in it the philoſopher's ſtone.

From the above account of the analyſis of the human ſpittle, little was known concerning it's component parts; but a more detailed analyſis has been made by Hapel de la Chenier on the ſaliva of the horſe, which it will be neceſſary to give ſome account of.

Saliva of the horſe by de la Chenier.

He collected it whilſt the animal was feeding, by making a puncture into the duct of the ſalivary gland; by this means he procured twelve ounces of it in the ſpace of 24 hours.

It's properties when examined externally, and by reagents.

It's colour was of a light greeniſh yellow, ſoapy to the touch; it's aroma weak but diſguſting; it's ſavour ſaline; it's conſiſtence thin, but by repoſe it became leſs fluid.

On expoſure to the air, it became putrid in fourteen days; was covered with a browniſh mouldy pellicle; became thinner, darker, and in ſix weeks was dry, reſembling a blackiſh earth. It does not undergo the acetous previous to the putrid fermentation.

Expoſed to dephlogiſticated air, this fermentation was retarded.

In boiling water it coagulated in part, which coagulum was not ſoluble in water.

Alcohol acted in the ſame manner, and precipitated

the coagulable part in the form of flocks, which were not only ſoluble in ammonia but in water.

Vitriolic acid diluted, coagulated it, and the remaining fluid afforded ſmall cryſtals of Glauber's ſalt, after filtration and evaporation.

Nitrous acid made it clammy, and a depoſit ſoon took place.

Marine acid made it tougher, the other acids thickened it more or leſs.

The coagulated part formed by the acids was not ſoluble in water like that procured by alcohol, but ammonia diſſolved it perfectly, and it was again precipitated by acids.

Solutions of the alkalis and neutral ſalts had no effect on this ſaliva; nor did cauſtic alkalis or lime water produce any ſmell of ammonia.

It precipitated metals from their ſolutions.

Earthy neutral ſalts cauſed a depoſit.

Oils and reſins become united with water by ſtirring them with the ſaliva; hence Chenier ſays, that it may ſerve to extract the fat from cloths like a ſoap.

In the heat of boiling water it became thinner and depoſited flocks, whilſt there went over on diſtillation a fluid diſagreeable both in ſmell and in taſte, which was neither acid nor alkaline. The reſiduum reſembled dried mucus, and became moiſt on expoſure to the air; diſtilled in a glaſs retort, it produced a lemon coloured very alkaline fluid, which changed the ſyrup of violets green; and an oil of the ſame colour, which ſwam on the ſurface. In the neck of the retort were cryſtals of volatile alkali, coloured by the oil; a thick, black, empyreumatic oil, which fell to the bottom of the liquor; then inflammable and fixed airs; there remained in the retort a coal, and the inſide was lined with a metallic ſplendour, which remained in it a quarter of a year.

The coal was difficultly incinerated, and the lixivium afforded cryſtals of muriat of ſoda.

Obtained by diſtillation.

	drm.	grs.
He obtained by this diſtilation, of water	1	5
Ammonia - -	0	....$3\frac{1}{2}$
Thick empyr. oil -	0	5
Inflam. and fixed air	0	5
Coal - - - -	0	....$6\frac{2}{3}$
Total....	1	...30

It's compoſition.

From Chenier's analyſis, this ſaliva conſiſts of air, water, mineral alkali, common ſalt, and an earth which he takes to be the earth of bones.

Saliva taken from the mouth of the horſe, in which it is mixed with other fluids therein, taſtes very evidently ſaline, and is of a more mucous conſiſtence than the other taken from the duct. It feels very ſlimy, has a nauſeous ſmell, but affords the ſame products by diſtillation as the other. Chenier found, however, that with lime and the cauſtic alkalis it produced a ſmell of ammonia, which was not the caſe with that from the duct.

It's analyſis very imperfect.

From this ſtatement of the analyſis of this fluid, it ſhows how imperfect our chemical knowledge is of it at preſent; a great many more experiments being neceſſary before it's component parts are ſufficiently underſtood.

A great analogy has been obſerved between this fluid and that which is ſecreted from the pancreas; their uſe appears to be the ſame, and both of a ſaponaceous nature.

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* Plenck's Hygrologie des Menſchlichen Korpers. art. Speichel.—Brugnatelli, in the Journal de Phyſique. p. 214. 1788.—Hapel de Chenier ſur la ſalive d'un cheval, in the Hiſtoire de la Societe Royale de Médecine, à Paris. p. 327, 333. an. 1780 & 1781.—Weber's Unterſuchung der Thieriſchen Feuchtigkeiten. Tubingen. 1780.

TEARS.

Before the experiments of Fourcroy and Vauquelin, this fecretion had never been analyfed; it is even very difficult to procure a fufficient quantity of it for examination, which may be one reafon of it's having been neglected.

The tears, when in a healthy ftate, are clear and tranfparent as water, they are without any aroma, their favour is evidently faline. Their properties.

Their fpecific gravity is fomewhat greater than that of diftilled water.

On expofure to a dry air, they evaporate fpontaneoufly to drynefs; and toward the end, cubic cryftals arife in the midft of a mucus, which ferves them as a mother ley. Thefe were found to be the muriat of foda, and foda in a free ftate. As the tears thicken on expofure, they become by degrees more yellow. They undergo no evident change from the impreffion of heat; on evaporation, the aqueous part firft comes over, and at the boiling point a foam appears, which is to be attributed to their mucous quality; then an oil, and there remains a dry yellowifh fubftance, fcarcely amounting to 00,4 of the quantity employed, which is a coal containing the phofphats of lime and foda in fmall quantity, being fcarcely perceptible; they have no effect on the tincture of litmus, but change paper coloured by violets to a green, which proceeds from the foda.

When frefh, they unite with cold and hot water in all proportions, if, however, they have been previoufly ex-

pofed to the air, fo as to have received from it a certain confiftence and a yellow colour, as before obferved, they remain unchanged, although from the foamy appearance of the water on agitation, a fmall portion feems to have been diffolved. By continued expofure, however, they become lefs and lefs foluble, which feems to arife from their union with oxygen.

Unite with oxygen.

Alkalis unite readily with them, by which they are rendered more fluid, and this is the cafe after they have attracted oxygen.

Of all the acids, the dephlogifticated muriatic only affords any thing remarkable on this fluid when frefh. It is coagulated by it into white flocks, and becomes yellow as when expofed to the air; thefe flocks, like infpiffated tears, are infoluble in water. The acid, by lofing it's fmell and properties, fhows that it has parted with it's oxygen to the tears, and accounts for the gum which is formed at the angles of the eyes during fleep.

The fulphuric and muriatic acids have no effect on frefh tears, but produce an effervefcence when they are oxygenated. In the firft cafe, fulphat of foda remains mixed with the mucous part; in the fecond, muriat of foda.

Alcohol, added to frefh tears in fufficient quantity, precipitates the mucous part in the form of large white flocks. If the fpirit be feparated from the mucus and evaporated, traces of muriat of foda, and of foda, appear, and by this method the proportion between the faline and mucous parts may be found.

Analyfis.

From the analyfis made by thefe two chemifts, it appears that tears are compofed of a peculiar mucus, which, after their water, forms the greateft portion of muriat of foda, phofphat of lime and foda, which laft forms fo

ſmall a part as to be ſcarcely perceptible, to which Plenck has added phoſphat of ſoda. From the limpidity of this fluid, it had been conſidered by many as water nearly in a pure ſtate; amongſt theſe was Pierre Petit, a Phyſician of Paris, who publiſhed a Treatiſe on the Tears, about the end of the laſt century. Some obſervers, as Schœner, &c. have likewiſe ſeen the formation of cryſtals in them, and they produce alkali according to Blaſius; but further inveſtigation is neceſſary before we can arrive at their component parts.

NASAL MUCUS.

This ſecretion is without ſavour or aroma. It is a tranſparent colourleſs fluid when it is freſh and thin; but when thickened, it is of a ſlight greeniſh yellow.

It's properties. It's conſiſtence is clammy, adhering to any thing it touches.

This ſecretion is more copious in childhood than at a ſtate of puberty.

It's ſpecific gravity is ſomewhat greater than that of water. It ſwims at firſt on the ſurface of water, but ſinks to the bottom as ſoon as the air is extricated from it.

Expoſed to the air, it becomes hardened into pulverizable ſhining leaflets.

On a red hot coal, it is nearly all evaporated without any diſagreeable ſmell, which is not the caſe when it is united with a little pus.

It neither unites with cold or warm water, nor is diluted by them; neither is it diſſolved by boiling water; ſince, according to Plenck, it falls to the bottom on cooling.

It has no action either on the tincture of litmus, or ſyrup of violets.

It appears to unite, in ſome meaſure, with limewater.

It does not unite oil with water like vegetable mucus.

It is neither ſoluble, according to Plenck, in neutral, nor carbonated alkaline ſalts, but by the cauſtic it is decompoſed.

The acids thicken it ſomewhat in ſmall quantities; in large they diſſolve it, and produce different colours.

The vitriolic acid gives it a purple red colour, and diſſolves it, except a few lumps which fall to the bottom.

The muriatic acid diſſolves it totally, with an ame-thyſt colour.

The nitrous acid when concentrated diſſolves it with a yellow colour.

Of all animal fluids, it appears to be one that is the leaſt ſubject to putrefaction. It remained a month, according to Plenck, expoſed to warmth in water without any ſmell.

Mucus appears to be the ſame as fibrin of the blood, with this difference, that it contains a little gelatin.

For the examination of the naſal mucus in a diſeaſed ſtate, we are indebted to Fourcroy and Vauquelin; the perſon from whom it was taken had an inflammation of the ſchneiderian membrane, or what is commonly called a cold, which is the beſt time to obtain it in any quantity. In a diſeaſed ſtate.

At the commencement of this diſeaſe, the mucus is clear and tranſparent as water, it's ſmell ſcarcely obſervable, it's ſavour ſaline and ſomewhat ſharp; in this ſtate it has a great reſemblance in it's properties with the tears; it contains like them muriat of ſoda, ſoda, and ſome particles of phoſphat of lime. To this may be added, that theſe two chemiſts having procured ſome of this naſal mucus quite pure from a perſon who had the inferior extremity of the lacrymal duct obſtructed ſo as to prevent the admixture of the tears, found it perfectly to agree in it's properties with that fluid.

When this humour runs more ſlowly, toward the end of the diſeaſe, it remains longer attached to the ſides of the naſal cavity, and there it undergoes ſeveral alterations; it becomes thickened by the heat of the inflammation, whilſt the inſpired air depoſits a portion of it's oxygen as it paſſes over it, and produces a puriform conſiſtence and yellowiſh or greeniſh colour. On expiration, a part of the carbonic acid uniting with the ſoda of the mucus, gives

it the property of precipitating imewater and barytic ſalts.

. Since, therefore, the naſal mucus has more conſtantly the acceſs of air than the tears, the laſt being only expoſed to it upon the ſurface of the eyes, and from it can only imbibe the oxygen, it follows that the naſal mucus contains more viſcous matter, has more tenacity than the tears, and on thickening, is generally of a more yellow colour than the tears in the naſal ſack.

Theſe chemiſts found, that the mucus obtained by the inſpiration of dephlogiſticated muriatic acid gas through the noſe had very ſimilar properties to that obtained by a common cold, except that the firſt portions contained no ſoda, nor changed the blue colours of vegetables to a green. At firſt the mucus flowed in great abundance, and was tranſparent as cryſtal; but afterward it became ſomewhat inſpiſſated, and put on the yellowiſh, greeniſh appearance of pus.

From theſe appearances, there is great reaſon to attribute this artificial cold to the oxygen of the marine acid, ſince it was found that the fumes of other acids, which contained no oxygen in a free ſtate, produced no ſuch action.

Plenck, art. Thranen—Examen chimique des Larmes, and de l'Humeur des Narines, &c. par Meſſrs. Fourcroy et Vauquelin. Journal de Phys. Sem. 2. p. 254. 1791. & Annal. de Ch. p. 113. v. 10.

PUS.

This, in a healthy ſtate, is a whitiſh fluid, ſecreted from the ſurface of an inflamed part, and is of the conſiſtence of cream. It's properties.

It's ſavour is mawkiſh, and it's aroma when warm is peculiar to it, when cool it is inodorous.

We are informed by Home, that when examined by the microſcope, it is found to conſiſt of two parts, viz. of white globules and a tranſparent colourleſs fluid.

It's ſpecific gravity is greater than that of water.

It does not readily go into the putrid fermentation.

According to Hildebrandt, by a moderate warmth it undergoes the acetous fermentation.

Heat does not coagulate it, but evaporates it to dryneſs.

By the dry diſtillation, Brugmann informs us, it gives an aqueous fluid, which is neither acid nor alkaline, then becomes thick and brown in colour; in a ſtrong heat, it affords an alkaline ſpirit, and ammonia in a fixed ſtate, an empyreumatic oil, and leaves a blackiſh ſhining coal, difficult to incinerate. The aſhes are very ſmall in quan- and of a dark reddiſh colour.

When placed on red hot coals, it produces an animal aroma and inflames.

It does not unite with water in the heat of the atmoſphere, but falls to the bottom; if, however, a conſiderable heat be applied, it riſes, and is diffuſed through the water; and remains mixed with it even after cooling, the globules appearing to be decompoſed.

Pus, from a gonorrhœa, and the ſmall or chicken pox, has the ſame appearance as that from a healthy ulcer.

It has no corroding action on flesh.

It shows the presence neither of a disengaged acid nor alkali.

Vitriolic acid, when concentrated, dissolves it, forming a darkish purple colour. On diluting the solution with water, the dark colour disappears, and the pus separates again in the form of a porous substance, part of which swims at the top, the other sinks.

Concentrated nitrous acid produces with it a lemon-coloured solution, and the addition of water separates a gray coloured substance from it.

Strong muriatic acid forms with it an ash gray coloured solution, from which water separates the pus in it's natural state.

Carbonated potash, according to Hildebrandt, mixes with pus, and about twelve times as much distilled water heated to 100° of Fahrenheit, and becomes of a gelatinous ropy consistence. Bad pus only gives a weak gelatin.

Neutral salts have no action upon it.

Caustic alkalis form with it a homogeneous, ropy, whitish fluid; the pus is again perfectly separated by water and acids.

Alcohol thickens it by attracting it's aqueous particles, but does not dissolve it.

Oils mix with it, but have no action in their mild state.

Distinguished from mucus by Darwin. Much has been said respecting the distinguishing properties of pus and mucus, and an ingenious Dissertation has been written by Charles Darwin upon this subject, who draws the following conclusions from his experiments: 1. Pus and mucus are both soluble in the vitriolic acid, though in very different proportions, pus being much the less soluble. 2. The addition of water to either of these compounds decomposes it; the mucus, thus

feparated, either fwims on the mixture or forms large flocci in it; whereas the pus falls to the bottom, and forms on agitation an uniform turbid mixture. 3. Pus is diffufible through a diluted vitriolic acid, though mucus is not; the fame occurs with water or a folution of fea falt. 4. Nitrous acid diffolves both pus and mucus; water added to the folution of pus produces a precipitate, and the fluid above becomes clear and green, while water with the folution of mucus forms a dirty-coloured fluid. 5. Alkaline lixivium diffolves (though fometimes with difficulty) mucus, and generally pus. 6. Water precipitates pus from fuch a folution, but does not mucus. 7. Where alkaline lixivium does not diffolve pus, it ftill diftinguifhes it from mucus, as it then prevents it's diffufion through water. 8. Coagulable lymph is neither foluble in diluted nor concentrated vitriolic acid. 9. Water produces no change on a folution of ferum in alkaline lixivium, until after long ftanding, and then only a very flight fediment appears. 10. Corrofive fublimate coagulates mucus, but does not pus.

The author thinks, therefore, that *ftrong vitriolic acid* and *water*; *diluted vitriolic acid*; and *cauftic alkaline lixivium* and *water* will ferve to diftinguifh *pus* from *mucus*; that the vitriolic acid can feparate it from coagulable lymph, and alkaline lixivium from ferum. And hence when a perfon has any expectorated material, the compofition of which he wifhes to afcertain, let him diffolve it in vitriolic acid, and in cauftic alkaline lixivium; and then add pure water to both folutions, and if there is a fair precipitation in each, he may be affured that fome *pus* is prefent; if in neither a precipitation occurs, it is a certain teft that the material is entirely *mucus*; if the material cannot be made to diffolve in alkaline lixivium by time and trituration, there is reafon to believe that it is pus.

According to Salmuth, who has examined this method of diſtinction, the criterion which that ingenious youth wiſhed to eſtabliſh cannot be relied upon, hence other methods have been propoſed.

Home. We are informed by Home that the property which characteriſes and diſtinguiſhes pus from moſt of the animal ſubſtances is it's being compoſed of globules. This property was firſt obſerved by John Hunter, and is an accurate means of knowing healthy pus.

Home found that mucus, and every other animal ſubſtance affected by the action of putrefaction, appear to be compoſed of flakes when examined by the microſcope; that this property of being compoſed of globules ſhows that pus has a great affinity to the other animal ſecretions, although in many circumſtances it may differ from them; viz. it differs from the blood in the colour of the globules, in their not being ſoluble in water, whilſt thoſe of the blood are, and from the fluid in which they ſwim being coagulable by a ſolution of ſal ammoniac, which ſerum is not.

It differs from chyle in it's globules being larger; not coagulable on expoſure to the air, nor by heat, whilſt thoſe of chyle are.

The globules of the pancreatic juice are much ſmaller.

Thoſe of milk are nearly of the ſame ſize as thoſe of pus, though much more numerous; but milk coagulates by rennet, which pus does not: and likewiſe contains oil and ſugar, which are not to be diſcovered in pus.

To try the comparative action which pus in the body, and pus and jelly out of it, had on fleſh, Home put a piece of fleſh into a healthy abſceſs, and equal weights of the ſame he immerſed in equal quantities of pus and jelly in two glaſſes, which were kept nearly in the temperature of the human body; and it appeared that in twenty-

four hours the fleſh in the abſceſs was quite ſweet; that in the pus had a ſlight putrid ſmell, and had decreaſed in ſize; that in the jelly was become ſmaller and finer in it's texture. In ſix days the fleſh in the firſt was leſſened, but quite ſweet; in the ſecond it was diſſolved in ninety-ſix hours, whilſt that in the jelly was not putrid, but much ſmaller. The muſcle in the abſceſs was preſerved a few days longer without undergoing any change or diminution in weight.

To determine this diſtinction likewiſe between pus and mucus, Graſmeyer has lately propoſed the following experiment. The ſubſtance to be examined is mixed by trituration with an equal quantity of tepid water, a ſaturated ſolution of perfectly aerated potaſh, equal in weight to the ſubſtance, is added, and the mixture being gently agitated is ſet aſide. If the mixture be pus or mixed with it, a tranſparent tenacious jelly will ſeparate in a few hours; on the contrary, if the mixture contain no pus, it will remain unchanged. Graſmeyer.

On diſtillation Brugmann obtained from $8\frac{1}{2}$ ounces of pus, in a heat of boiling water, $7\frac{1}{4}$ of a tranſparent water without ſmell, which contained neither an acid nor an alkali; by a ſtrong heat, 3 drachms of an empyreumatic ammoniacal fluid; 2 ſcruples of the ſame mixed with an oil, $\frac{1}{2}$ drachm of dry ammonia, and $\frac{3}{4}$ of an ounce of an empyreumatic oil, and the remaining coal contained, when incinerated, iron, calcareous earth, and no ſalt.

In a ſtate of diſeaſe, as in ſcrofulous abſceſſes, pus conſiſts, according to Home, of globules and flaky particles floating in a tranſparent fluid; the flaky part is greater in proportion to the ſmallneſs of the inflammation; and in thoſe abceſſes unaccompanied by inflammation, their whole contents are curdly and flaky; whilſt in irritable ulcers the diſcharge is often thin, being In a diſeaſed ſtate.

principally compofed of an aqueous fluid of an irritating nature, and very much inclined to become putrid. According to Crawford, the pus from the cancer conftantly changed the firup of violets green, which he attributes to it's containing ammonia; and potafh produced no change in it. Sulphuric acid coloured it brown, and difengaged with an effervefcence a difagreeable odour refembling fulphureous hydrogenous gas. From his experiments Dr. Crawford concludes, that this pus contains a principle poffeffing many properties of hepatic air, which he thinks is combined with the ammonia, and he calls it animal hepatic gas. This pus, diluted with water and diftilled, afforded at firft the air of the retort charged with the cancerous odour; this was fucceeded by fome whitifh vapours with a putrid odour. When the water was entirely evaporated, a new gas arofe exhaling the odour of burnt bones, with fome empyreumatic oil. It appears, therefore, to Dr. Crawford, that the ftinking odour of this pus is a volatile fubftance, which forms the nidus for the cancerous poifon.

In the cancer, by Crawford.

Dr. Crawford is of opinion, refpecting the matter of the cancer, that chemical changes and combinations take place; his reafons for thinking fo are, that in the cancer, and in malignant ulcers, the animal fibre undergoes nearly the fame change as in dry diftillation. The purulent matter neceffary to the cure of the ulcer is in this cafe mixed with the animal gas and ammonia.

This compofition, which may be called an ammoniacal fulphure, attacks metals and decompofes metallic falts, for when it is enclofed a few days upon mercury, it changes it's furface to a black colour, and it immediately precipitates the folution of nitrat of filver of the fame colour. Thefe facts appear to Crawford to explain what takes place on applying metallic falts to a malignant ulcer, the ammonia unites to the acid of the falt, and the hepatic

animal gas reduces the metal by ſeizing it's oxygen. (According to Crawford, by reſtoring to it the inflammable principle).

It is probable, that the metal thus reduced is ſometimes attacked again by the ammoniacal ſulphure, which gives it a black colour. The ſame origin may be aſcribed to the black cruſt formed on the tongue and in the mouth, when venereal ulcers of the throat are waſhed with a ſolution of corroſive muriat of mercury; to the obſcure colour which cataplaſms made of the acetite of lead have upon bad ulcers; and to the change which ſounds ſometimes undergo after having been introduced into the ſinuses of ſuch ulcers, or applied to carious bones. Hence, undoubtedly, is the reaſon of poliſhed metals ſo eaſily tarniſhing on expoſure to the putrid effluvia of animal ſubſtances.

Hepatic animal gas, Dr. Crawford found, communicates a green colour to recent fat; it renders animal fibres ſoft and flaccid; it accelerates putrefaction; hence it is a ſeptic, and it is very probable that the compoſition reſulting from it's union with the ammonia, contained in the liquor running from an open cancer, produces deleterious effects and aggravates the diſeaſe. It is the ammoniacal ſulphure that communicates to the cancerous matter it's putrid odour, it's tenacity, and all the properties that diſtinguiſh it from ordinary pus.

According to Dr. Crawford, therefore, a ſubſtance capable of decompoſing the ammoniacal ſulphure, and of deſtroying the fetor of the animal hepatic gas, without increaſing the mortification of the veſſels, would neceſſarily produce ſalutary effects. The nitric acid only deſtroys this fetor at a high degree of concentration, and in this ſtate it is corroſive. On the contrary, this gas is deprived of it's fetor as ſoon as it is mixed with the oxygenated muriatic acid, even diluted with three times it's

weight of water; the application can then be made without danger, provided the cancerous ulcer be not very irritable.

In the hofpital fore by Cruickfhank.

The matter of the *hofpital fore*, which is produced, according to Dr. Rollo, by a poifon *fui generis*, as are the venereal, fcrofulous, cancerous, and variolous fores, has been examined by Cruickfhank.

This matters appears to be fparingly foluble in water, but being readily diffufed through it produces a milkinefs.

It produces no effect on the infufions of litmus or Brafil wood, hence is neither acid nor alkaline.

Pure ammonia reduces it to a tranfparent jelly, and after fome time diffolves the greater part of it; the fame happens to pure pus.

Acids, and particularly the fulphuric, precipitate but partially thefe folutions.

The folution of nitrat of filver, poured into the filtered aqueous folution of this matter, occafions a whitifh precipitate.

The fame effect is produced by the nitrat and muriat of mercury; but the precipitate is much more abundant. When pure pus is treated in the fame manner, thefe precipitates, particularly that by muriat of mercury, have fomewhat of a different appearance, difficult to defcribe.

Limewater rather changes it's fetid odour, but does not deftroy it; fulphuric acid increafes it; alcohol, and a folution of the oxyd of arfenic in potafh, produce the fame effect. This fetor refifts the decoction of Peruvian bark; on the contrary, it is deftroyed by the nitrats and muriats of mercury, by the nitrous acid, but more completely by the oxygenated muriatic acid, either in a liquid ftate or in the form of gas. The nitrat of filver produces very little change either in it's colour or odour,

which is the more remarkable from this falt having the property of deftroying the moft offenfive odours, even that of the matter of the cancer.

Cruickfhank is of opinion, that the bad odour of this matter of the ulcer is produced by a change of one part of the true pus; for every ill conditioned difcharge has more or lefs fmell, while good pus has none; and fince it is a principle in chemiftry, with only few exceptions, that the odour of a fubftance cannot be entirely deftroyed without changing it's properties at the fame time, there is reafon to think, that if the odour of this peculiar morbific matter be entirely deftroyed by the addition of the nitrat or muriat of mercury, the oxygenated muriatic acid, &c. it's properties will be likewife changed.

Suppofing then, that an acid matter produced by fome means on the furface of a fore is able to produce ulceration of a fpecific kind, and that this ulceration, like that of the venereal vifcus, is able to propagate itfelf by forming a fimilar matter, or even to induce a general affection of the fyftem; there are feveral important confequences might be drawn from thefe experiments.

1ft. A fore, once clean, might be preferved from the effects of the matter alluded to, and even it's generation prevented, by wafhing it at every dreffing with a weak folution of nitrat of mercury, or with the oxygenated muriatic acid.

2d. When this matter begins to form, it's progrefs may not only be ftopped, but that already formed may be deftroyed by the application of a proper topic. In this cafe, the above experiments fhow, that the moft preferable are the moft active mercurial preparations, fuch as the muriat of mercury, or the precipitated red oxyd of the nitrat of mercury, which has not been entirely edulcorated. If it be neceffary to employ actual cauftic, the beft method is that of Humpage, which confifts not

in the application of the nitrat of ſilver, but in applying to the part a ſmall piece of linen dipped in ſome concentrated nitrous acid, which occaſions leſs pain than the other.

Reſpecting the action of different ſubſtances employed as cauſtic applications on ſores, they may be diſtinguiſhed into four.

1ſt. Subſtances producing a violent action, ſo as to occaſion the death of the part to which they are expoſed, ſuch as

Arſenic,
Muriat of mercury.

2d. Subſtances acting ſimply by burning or deſtroying the part, the action of which is always limited, as

Nitrat of ſilver,
Nitrat of mercury,
Nitric acid.

3d. Subſtances acting as menſtrua, the action of which it is difficult to limit, as

Common lunar cauſtic,
Mixture of potaſh and lime.

4th. Subſtances acting chemically on the part, by decompoſition as

Oxygenated muriatic acid, either
united with water or
in a ſtate of gas.

Dr. Rollo. We are informed by Dr. Rollo, that by chemical means he was ſo fortunate as to deſtroy the morbid poiſon of the hoſpital ſore; for this purpoſe he made uſe of the oxygenated muriatic acid, the nitrats of ſilver and of mercury, and the oxygenated muriatic acid gas. He began by waſhing the ſore with warm water; the ulcerated part was then immediately touched with the nitrat of ſilver; the ſore was afterward moiſtened with a diluted ſolution of nitrat of mercury, or

a mixture of oxygenated muriatic acid and diftilled water, and the whole was then covered with a linen cloth which had imbibed both. The oxygenated muriatic acid gas was alfo applied to the ulcer, and the diluted folution of nitrat of mercury on the whole of the fore. By this treatment the fore foon became cicatrized, and it only failed when the ulcer was too extenfive to be entirely acted upon by the nitrat of mercury or the oxygenated muriatic acid gas.

Home on Ulcers.—Hildebrandt's Anfangsgrunde der Ch.—S. I. Brugmann, Differtat. de Puogenia. Gron. 1785.—Experiments eftablifhing a Criterion between mucaginous and purulent Matter, by Charles Darwin. Litchfield, 1780.—Henr. Salmuth de Diagnofi Puris. Goett. 1783.—Hermann Grafmeyer's Abhandlung von Eiter and den Mitteln ihn von allen andern Feuchtigkeiten zu unterfcheiden. Gottingen, 1790.—Pus of the Cancer by Dr. Crawford, Annales de Chim. tom. 12. p. 149.—An account of two cafes of the Diabetes mellitus, by J. Rollo, M. D. with the refults of the trials of various Acids and other Subftances, in the treatment of Lues venerea, by Wm. Cruickfhank, 2 vol. Dilly, London, 1797, and Annal. de Ch. No. 86, p. 209.

SYNOVIA.

This is a tranſparent glutinous fluid, which is ſecreted between the articulations of animals to preſerve them from friction. The nature of this fluid was very little known before the experiments of Marqueron on that of the ox.

It's properties.

It is of a whitiſh green colour, has an animal aroma reſembling that kind of mucus found on the exterior of frogs.

It's ſavour ſomewhat ſaline.

It's ſpecific gravity is greater than that of diſtilled water. On being taken from the joints it becomes of a gelatinous conſiſtence, but does not continue long ſo, it is then as tenacious as before; at laſt it is fluid and gives a depoſit. If, however, it be filtrated on being received from the joints, it does not become gelatinous.

It changes green the blue colour of vegetables, and precipitates lime from it's aqueous ſolution.

It unites with water and makes it gelatinous; even one part of ſynovia gives ſix parts of water very evidently this property. The mixture effervefces on agitation; if boiled, it loſes it's tranſparency and receives a milky colour, and there ariſes to the ſurface a coagulated lymph; but although one part of the glutinous maſs has been thus ſeparated by boiling, the mixture ſtill retains a glutinous appearance. If a very diluted acid be added to this mixture, there ariſes a ſingular effect, whether in the warm or cold way. It becomes in an inſtant quite tough, which toughneſs it loſes on being ſtirred. It then becomes clear and tranſparent, and a peculiar ſubſtance ſeparates which is gluey and elaſtic. For this experiment vinegar is the beſt, as a concentrated acid cauſes

no ſeparation. The remaining liquor ſtill retains ſome albuminous matter, which on evaporation appears in the form of a pellicle.

Carbonated alkalis mix readily with ſynovia; but cauſtic render it fluid.

Concentrated acids precipitate a flocky ſubſtance from it, which is ſoluble again in the acid. When diluted, they coagulate it.

Alcohol, without depriving it of it's glutinous appearance, likewiſe ſeparates a flocky matter from it.

By diſtillation it ſhows nothing peculiar; there ariſes a water which eaſily putrifies, an empyreumatic oil, and ammonia. In the remaining coal alkali and muriat of ſoda are found on lixiviation; and when incinerated the aſhes afford phoſphat of lime.

Hence it ſhows the properties of the white of the egg. It is ſoluble in water and in an alkali, with which laſt it effervefces on agitation; it coagulates by heat or by acids or alcohol; but it appears to demand further inveſtigation, ſince it is a peculiar liquor that contains two ſpecies of albumen: 288 grains of ſynovia by chemical analyſis afforded

Analyſis.

Albumen in a peculiar ſtate	34 grs.
Common albumen	13
Muriat of ſoda	5
Carbonat of ſoda	2
Phoſphat of lime	2
Water	232
	288 grs.

According to Hatchett, 480 grains of ſynovia did not yield more than one grain of phoſphat of lime.

Mémoire ſur l'Examen de la Synovie, par M. Marqueron, Journ. de Phys. ſem. 2. p. 463. an. 1792.

SPERMA VIRILE.

The component parts of this fecretion were but little underftood before the experiments of Vauquelin, which have not, however, thrown any light on the caufes of it's very extraordinary properties.

Confiftence. Semen, as it comes from the body of a young healthy perfon, prefents itfelf under two forms: one part is fluid and milky, and the other of the confiftence of a thick mucus, in which is to be obferved a number of white fhining threads, more particularly if it be agitated in cold water.

According to Plenck, it is yellowifh in the tefticles, and of a dark yellow colour in the veficulæ feminales; by frequent emiffion it is whitifh. In perfons under the jaundice, and thofe who have taken faffron, it is yellow, whilft in a perfon who had the black jaundice it was black.

Examined by the microfcope. Lewenhöeck, Hartföecker, Baker, Haller, Buffon, and Spallanzani, have amufed themfelves with the examination of this liquor under the microfcope, in which they obferved numberlefs animalcula or vermiculi, the laft has even written their hiftory, whilft various theories have arifen from the fpeculative mind of genius, to account for the procefs of generation from the appearance of fuch minute beings.

Cryftallization. In Rofier's Journal de Phyfique for January 1784, p. 437, is a memoir in which the author obferves, that if this liquor be examined from the 12th to the 72d hour after it's extraction, and before it becomes putrid, and is in a tranquil ftate, from the death of thefe animalcula, each drop is found to contain a number of very fmall, light, brilliant cryftals, either fwimming on the liquor

or ſuſpended in it. This experiment muſt be tried in a place where no duſt can moleſt it, and where the heat is neither above 25° nor below 5° of Reaumur. Theſe cryſtals are ſpindleſhaped, or rather conſiſt of cones oppoſed at their baſis, and the ſides of which, inſtead of being ſtraight lines are rather convex; ſome are iſolated, others in groups, their dimenſions varying from $\frac{1}{50}$ to $\frac{1}{300}$ of a line in a diameter. Some of theſe are even ſo large as to be ſeen by the naked eye; they neither deliqueſce nor effloreſce. It appears that this ſaline ſubſtance is not found until after a certain degree of ſpontaneous evaporation. Theſe cryſtals ſeem to have eſcaped the obſervation of Haller, and ſome other natural philoſophers who have examined this liquor. They ſaw no cryſtals, although they were very deſirous to complete it's analyſis. He tells us, that this liquor, diſtilled in a ſand bath, afforded a phlegm, a quantity of fetid oil, a little volatile ſalt, and a good deal of earth. We are, however, not informed of what this volatile ſalt was compoſed; it could not be the cryſtallized ſalt above mentioned, which appears to have been a neutral ſalt, nearly inſoluble in alcohol, not volatile, far from deliqueſcing, and only ſoluble in a very large quantity of water; it likewiſe appears to exiſt entirely developed in the ſeminal liquor, in which there could be no appearance of ammonia at ſo early a period. Theſe cryſtals, however, which the author of the memoir appears to be ſo deſirous of being brought to light, are moſt probably the ſame which Vauquelin found in his examination, an account of which will be given.

According to Vauquelin, the ſavour of this fluid when freſh is ſharp, pungent, and ſomewhat aſtringent, contracting the organs of taſte; it's aroma is inſipid, like that of moſt other animal ſubſtances. On the contrary, we are told by Plenck, that it's aroma is of a peculiar kind, Experiments according to Vauquelin. It's properties.

very ſtrong to the organs of ſmell, and not unpleaſant. That the ſame ſmell is found in the roots of orchis, in the down of cheſnuts, and in the anthers of ſeveral plants. In ſome quadrupeds, this aroma is ſo ſtrong and penetrating in the ſeaſon of their amours, as to taint the fleſh; hence the fleſh of the goat at this period is not eatable.

With reſpect to it's ſpecific gravity, it differs according to circumſtances, but it is always heavier than diſtilled water, in which it immediately ſinks to the bottom if it has not previouſly imbibed a few particles of air. If rubbed in a mortar it becomes pituitous and thick, reſembling pomatum, which Vauquelin attributes to the admixture of air. When freſh, it changes the blue colours of vegetables to a green, and precipitates calcareous and metallic ſalts from their ſolutions, all which indicate the preſence of a diſengaged alkali.

The thick mucous part of the ſemen, on loſing a part of it's caloric, becomes tranſparent and of more conſiſtence than when juſt emitted; but it's greateſt peculiarity is, it's becoming fluid again in a few hours when cool. It likewiſe diminiſhes in weight in proportion to the loſs of caloric, &c. Theſe appearances are not to be accounted for from the knowledge we have of this fluid at preſent.

Curious appearance.

Expoſed to an air of 10° or 12° of Fahrenheit, after having undergone this change to a fluid ſtate, it becomes covered with a tranſparent pellicle, and after three or four days Vauquelin found a depoſit of ſome very delicate tranſparent cryſtals, about a line in length, ſome of them in a cruciform poſition. Examined by a magnifier, theſe cryſtals appeared in the form of quadrilateral columns, terminated by very elongated quadrilateral pyramids, and were phoſphorated calcareous earth, which it had previouſly held in ſolution. In a few days more

this pellicle becomes thicker, full of white round corpuſcles; the liquor becomes more fixed, and it's aroma ſomewhat reſembles ſweet whey. If from the ſtate of the atmoſphere the evaporation goes on very ſlowly, other cryſtals form of different ſhapes. Sometimes they are rhomboidal plates, at other times ſix ſided or rectangular priſms, or octoedral, and Vauquelin found them to be ſoda which had united with the carbonic acid of the atmoſphere. At the temperature of 18° or 20° this ſemen becomes ſemitranſparent like horn, and ſnaps between the fingers.

If the temperature be greater, as at 20° of Reaumur, the air moiſt, as at 75 of the hygrometer of Sauſſure, it is changed before it has time to evaporate to dryneſs; it becomes yellow like the yolk of an egg, ſour, and ſmells like putrid fiſh. Vauquelin, likewiſe, found it covered with the byſſus ſeptica.

Caloric has very little ſenſible action upon freſh ſemen; it only accelerates it's liquefaction, and when in this ſtate it does not coagulate it, as it does many other animal ſubſtances.

If the caloric applied be ſo great as to ſeparate it's principles, the aqueous part is firſt expelled, it then becomes evaporated to dryneſs, ſwells, blackens, emits yellow empyreumatic ammoniacal vapours, and leaves a light eaſily inflammable coal, which, by lixiviation and evaporation, affords rhomboidal cryſtals of carbonat of ſoda, and the remainder, on incineration, is reduced to white aſhes which contain phoſphat of lime.

Freſh ſemen is not ſoluble either in cold or hot water, but when evaporated to dryneſs it is ſoluble in both, and it is ſeparated from them in the form of white flakes, either by alcohol, or dephlogiſticated muriatic acid,

Acids diffolve it, and the folution is not afterward decompofed by alkalis.

Coagulated by dephlogifticated muriatic acid. The dephlogifticated muriatic acid is, however, an exception; for inftead of diffolving frefh femen, it coagulates it into white flakes, which are infoluble in water or acids. The fame takes place if the femen be in a liquid ftate. It is obferved by Vauquelin, that a large quantity of the acid gives it a yellow colour, like the thin matter of a gonorrhœa; this is owing to the fixation of the oxygen, for the acid lofes it's odour afterward.

Alkalis, when fufficiently ftrong, facilitate it's union with water.

Lime has no effect on frefh femen, but after it's expofure to a moift atmofphere for fome time, a confiderable quantity of ammonia is produced.

Neutral falts are not decompofed by it even in a liquid ftate; but the cafe is otherwife after a long expofure to the air when the rhomboidal cryftals are formed.

It's analyfis. According to Vauquelin's analyfis, one hundred parts of human femen contain of

Water	90
Fibrin	6
Soda	1
Phofphat of lime	3
Total	100

Conclufion. From the facts already mentioned in the inveftigation of this animal fecretion, it appears, that there are many curious circumftances attending it,

1. It's becoming fluid out of the body.

2. It's infolubility in water before it's fluidity, and it's folubility afterward.

Thefe two properties, Vauquelin is of opinion, arife from it's animal and mucilaginous nature.

3. The folubility of the phofphat of lime in this liquor.

4. It's cryftallization by fo moderate an evaporation.

Obfervation fur la Liqueur feminale, Journal de Phyfique, p. 437. Jan. 1784.—Expériences fur la Sperme humaine, par M. Vauquelin, ibid. p. 58. fem. 2. 1791.—Tracts on the nature of Animals and Vegetables, by Spallanzani. Creech. 1799.

HUMOR A VESICATORIO.

It is a well known fact, that when cantharides are applied to the ſkin in the form of a plaſter, an elevation of the cuticle takes place, and the bliſter is filled with a fluid reſembling water in it's external appearance. For the examination of this ſerum or ſeroſity, as it has been called, we are indebted to Margueron. His principal intention was to diſcover it's nature, and to what claſs of humours it belonged; on which account he analyſed it both in a ſtate of health, and when taken from patients labouring under putrid fevers. He found that by frothing with water, by it's coagulation with alcohol, boiling water, acids and heat, and from the different ſalts it contained, it reſembled the ſerum of the blood; and on comparing them together, he concluded that the great difference between them conſiſted in the odour and colour, the ſeroſity being of a darker or amber colour, and poſſeſſing the ſmell of the bliſtering plaſter. The fluidity of the ſerum, however, was more viſcous, whilſt the ſeroſity on coming from the veſicles afforded a pellicle. The ſpecific gravity of the ſerum to the ſeroſity was as 305 to 300, and 200 parts of each gave, on analyſis, the following proportions.

Examined by Margueron.

Reſembles the ſerum of the blood.

Difference.

Analyſis.

	SERUM.	SEROSITY.
Albumen	40	36
Muriat of ſoda	4	4
Carbonat of ſoda	3	2
Phoſphat of lime	2	2
Water	151	156
	200	200

This chemiſt is of opinion, that the colour is cauſed by the action of the veſicatory in exciting heat, inflammation, &c. as he found the colour the ſame whether it was procured from a healthy or diſeaſed perſon. From theſe experiments, therefore, it appears, that the feroſity and ſerum are ſimilar in their properties and both extracted from the blood.

This analogy induced this chemiſt to examine that ſeroſity or aqueous fluid produced by ſinapiſms, by burns or ſcalds, and by the ſting of inſects, or by the ant, as well as that which is the effect of cutaneous diſeaſes; and he found on ſubmitting them to experiment, that they had all the ſame properties as the ſerum of the blood, and conſequently that all aroſe from the ſame origin.

Examen chimique de la Sérofité produite par les Remèdes véficaires, par M. Margueron. Annal. de Ch. tom. 14. p. 225.

HUMOR HYDROPIS.

Resembles the last.

The fluid which is secreted in the various species of dropsies of the body, is likewise similar to the last mentioned liquid. It is in general somewhat yellow, scarcely turbid, and resembles even in it's external appearance the serum of the blood. It has a peculiar smell, which in some cases, as in the milk fever, is apparently acid. It is saline to the taste, and tinges violets green. Left to itself, it first becomes turbid, and at last putrefies. Boiling water coagulates the greater part of it; poured into hot water it forms a milky fluid which is incoagulable by nitric acid. It is also coagulated by all acids; alkalis rather dilute it, and when mild, precipitate in a few hours a gelatinous substance which is considered as a proof of the presence of pus. The white, opake, and seemingly unctuous membrane (pseudomembrana Ruyschii) which often accompanies this humour in dropsies, agrees in it's properties with the fibrous part of the blood, and with it's buffy coat. By heat, or exposure to air, it dries into a horny substance, but in moist air it speedily putrefies. When triturated with water, it forms an imperfect solution, from which mild alkalis precipitate a gelatinous matter.

Jacquin's Elements of Chemistry. p. 363. 1799.—Buckholz Chemische Untersuch. der Feuchtigk. von einem Wassersucht. Crell's Annal. 2. 1786.

LIQUOR AMNII.

It is ſtated by Haller on the authority of ſeveral reſpectable authors, that the human liquor amnii is not very unlike the ſerum of milk in it's properties, even in it's odour; that it is ſomewhat ſaline to the taſte, and is coagulated by alum, alcohol, and the infuſion of galls. Some authors who look upon this fluid to be the food of the fœtus in utero, are likewiſe inclined to believe that it has all the properties of albumen or the white of the egg, which is the nouriſhment of the chicken before it breaks the ſhell, and ſo far it favours their hypotheſis; great care ſhould however be taken in making experiments of this kind, that the mind be unbiaſſed by any previous prejudice, as in ſuch caſes it often is apt even to deceive itſelf. Haller's opinion.

A few years ago, this aqueous fluid was chemically examined by a Dutch chemiſt, Van der Boſch, whoſe veracity is as much to be relied upon as that of thoſe quoted by Haller, or thoſe authors who have written ſince upon the ſubject. This chemiſt applies the fruit of his experiments to phyſiology, and attempts to prove that the fœtus in utero receives no nouriſhment from this fluid. Van der Boſch.

He examined the liquor amnii of the cow and that of the human female, and found that it's quantity is in the inverſe proportion of the ſize of the fœtus, and that in the firſt ſtage of pregnancy it's weight exceeds that of the fœtus from twenty to one hundred times. It's colour during the firſt months is clear, or has a ſlight yellow hue, but towards the birth, it is turbid, flocky, and

ſometimes has a reddiſh tinge. It's ſmell is ſcarcely obſervable, reſembling the ſteam of a newly-ſlain animal. It's ſpecific gravity is not very different from that of common water, but at birth it is ſomewhat heavier and gives a copious depoſit. From experiments, it conſiſts for the moſt part of mere water, and is of all animal fluids the moſt aqueous. It does not coagulate by any means. It contains an exceedingly ſmall quantity of common ſalt and fixed alkali, and a very little phoſphoric acid. It produces leſs volatile alkali and empyreumatic oil than any other animal fluid. It contains a little earth and red calx of iron, and the conſtituent parts and properties of that of the cow in the firſt months of pregnancy were found perfectly to agree with that of the human female, procured at the time of delivery, except that it is more aqueous.

From theſe facts, the author concludes, that although the liquor amnii has been commonly compared to the white of the egg; yet this laſt coagulates by heat and acids very readily, the liquor amnii not at all; and for the ſame reaſon it differs from ſerum of the blood, and the liquor pericardii.

It does not agree with whey, for this laſt contains a large quantity of an eſſential ſaccharine ſalt, the liquor amnii none at all.

It differs from animal broth or ſoups, for it does not coagulate in the cold, or undergo the acetous fermentation.

Laſtly, it differs from urine, for it ſcarcely contains an atom of volatile alkali, whilſt urine affords it in large quantity; and the author affirms that it's uſe is to protect the fœtus from external preſſure; that it aſſiſts in expanding the womb, renders the parts ſupple, and is of great ſervice at the time of delivery.

With refpect to the coagulation of this fluid, it appears from the experiments of John Hunter, that it contains but a very flight quantity of matter coagulable by heat. John Hunter.

The moft perfect and detailed analyfis of the liquor amnii, has been made by Buniva and Vauquelin; they not only examined that of the human female, but likewife that of the cow. Suppofing there would be great fimilarity between the liquor amnii of different animals, they began with the human, but they foon found that no fuch refemblance exifted, and that no two things were more unlike than the human and that of the cow. Buniva and Vauquelin.

LIQUOR AMNII OF THE HUMAN FEMALE. Human liquor amnii.

1ft. It has a mild and infipid odour like all the white fluids of animals. It's properties.

2d. A flightly faline favour.

3d. It's colour is fomewhat milky, owing to a cafeous matter which is fufpended in it, for it may, by filtration, be obtained clear and tranfparent.

4th. It's fpecific gravity is as 1005.

5th. It foams confiderably on being agitated.

6th. On expofure to heat, an opacity is produced refembling that of milk greatly diluted with water, and a fmell of the boiled white of an egg.

7th. It ftrongly changes the tincture of violets to a green, but flightly reddens the tincture of litmus.

8th. Potafh produces a flaky precipitation of animal matter, which feems to have been diffolved by a flight acid.

9th. Acids only clarify it.

10th. Alcohol produces a flaky precipitation, which

being collected and dried, is brittle and tranſparent as glue.

11th. A very large brown precipitate is formed with the infuſion of galls.

12th. The nitrat of ſilver produces a white precipitate, inſoluble in the nitric acid.

From theſe properties, theſe two chemiſts conclude that the human liquor amnii contains,

1ſt. An albuminous matter reſembling that of the blood, appearing to be held in ſolution by a ſlight acid.

2d. A muriatic ſalt, with ſoda for it's baſis.

3d. A ſmall proportion of alkaline matter. It appears difficult to admit the preſence of an acid and an alkali at the ſame time in this liquor, in a free ſtate; and indeed theſe chemiſts do not ſay there is really an acid, but that it acted as if it contained one, for it reddens the tincture of litmus, is precipitated by cauſtic potaſh, and depoſits by fermentation an earthy animal matter, from which ammonia is extricated.

Evaporation of it.

On evaporation, the liquor amnii, 1ſt. becomes ſlightly milky. 2d. There ariſes a tranſparent pellicle on it's ſurface. 3d. A reſidue is left, the weight of which at moſt amounts to 0,012 of the whole.

The edulcorated reſidue, on evaporation, afforded cryſtals of muriat and carbonat of ſoda. The animal matter, lixiviated, gave, on being burnt, a fetid and ammoniacal odour, nearly like that from horn; there remained a few aſhes compoſed of carbonat of ſoda, of phoſphat and carbonat of lime.

It's component parts.

Theſe experiments prove that the human liquor amnii only contains a very ſmall portion of ſaline and animal matter, diſſolved in a large quantity of water, ſince the different ſubſtances together ſcarcely amounted to 0,012 of the liquor, and theſe are albumen, ſoda, muriat of ſoda, and the phoſphat of lime.

The liquor amnii kept in a clofed bottle undergoes in the courfe of a few weeks a putrid decompofition; it lofes it's tranfparency, and depofits a white matter like cheefe. During this change, a little ammonia is evolved, but no gas or bad fmell. Putrid fermentation.

CASEOUS MATTER.

Cafeous matter.

This fubftance is white and fhining, foft to the touch, and refembling newly made foap. It is infoluble in water. Alcohol, even with the affiftance of heat, has no effect upon it. Oils do not unite with it. Cauftic alkalis diffolve a portion forming with it a kind of foap, at leaft judging from it's odour, favour, and the property of being precipitated by acids. It decrepitates like falt upon red hot coals, then becomes dry, blackens, and fends forth empyreumatic oily vapours. Laftly, a large quantity of coal is left difficult to incinerate. It's properties.

Heated in a crucible of platina, it likewife decrepitates, and an oil exudes from it. It fhrivels like horn, inflames, and leaves a gray cinder that effervefces with acids, the greater part of which is compofed of carbonat of lime.

From thefe properties it would appear, that this cafeous fubftance is a mixture of animal mucilage and fat; but it is more probably a peculiar fubftance, the origion of which thefe chemifts attribute to a degenerate ftate of the albuminous matter, taking a fat character. This change is not more extraordinary than the converfion of the fœtus into fat on remaining in the uterus beyond the natural time. It's compofition.

It is this kind of matter which is found depofited upon the body of the fœtus, particularly under the armpits, behind the ears, and on the groins, where it is fometimes Utility of it.

in large quantity. It ferves by it's foftnefs, unctuofity, and it's impenetrability to water, to anoint the fkin of the fœtus, and prevent any bad effects of the liquor amnii; at the fame time it favours it's birth during delivery.

LIQUOR AMNII OF THE COW.

Liquor amnii of the cow differs from the human.

This liquid differs from that of the human fubject, 1ft. By a fallow red colour. 2d. An acid favour mixed with a bitternefs; an odour refembling certain vegetable extracts. 3d. A fpecific weight equal to 1.028, and by a vifcofity approaching that of a folution of gum.

Properties of it.

1ft. It reddens ftrongly the tincture of litmus.

2d. It forms a large precipitation with the muriat of barytes.

3d. Alcohol feparates a large quantity of reddifh matter from it.

Evaporation.

On expofing the liquor amnii of the cow to evaporation, a thick foam was formed, eafy to feparate, in which, when cool, fome white flightly acid cryftals were obferved. It became thick, vifcous, and yellow, like a kind of honey, of which it had nearly the fhade. Treating this matter with boiling alcohol, it afforded an acid, which, on the cooling of the liquor, cryftallized into fhining needles, feveral centimetres in length. The extractive fubftance being infoluble in alcohol, remains in the form of a gluifh compact pitch. In order to deprive it completely of it's acid, it is neceffary to boil it feveral times in a large portion of alcohol, and by evaporating the menftruum, the acid it diffolves is obtained. To prevent any of the extractive matter from being diffolved with the acid in the alcohol, the liquor amnii muft be evaporated to a thick confiftence, for humidity favours

An acid obtained, the amniotic.

it's ſolution. It was by treating in this manner the reſiduum, that theſe chemiſts diſcovered an acid in this liquor; but they found afterward that alcohol was not neceſſary to ſeparate it, that it was ſufficient to reduce the liquor to one fourth, to obtain, on cooling, the greater part of the acid. It is indeed much whiter and purer when extracted by alcohol, from being deprived of all the animal matter that may remain attached to it's cryſtals, formed in a thick fluid; but it can be purified by waſhing it with a little cold water, which readily diſſolves the extractive matter, and ſcarcely at all the acid. (*Vide* acids, amniotic acid.)

The liquor amnii being deprived of it's acid, if the evaporation be continued until it has acquired the conſiſtence of ſirup, large tranſparent cryſtals are formed that are very ſoluble in water and of a bitter colour. Theſe chemiſts found it to be the ſulphat of ſoda. It is in pretty large quantity. To obtain it pure they burnt the reſiduum of the exſiccated liquor, and by lixiviating the aſhes, obtained a ſolution which afforded on evaporation perfectly pure cryſtals of this ſalt.

THE EXTRACTIVE ANIMAL MATTER.

The animal extractive matter.

THE animal matter which accompanies the above ſalts in the liquor amnii of the cow, theſe chemiſts found to be of a peculiar nature, with no perfect reſemblance o any at preſent known.

It's properties.

It is of a brown red colour, has a ſingular ſavour difficult to deſcribe; it is very ſoluble in water, and inſoluble in alcohol, which even ſeparates it from the water. This laſt property, with that of giving viſcoſity to water, and the faculty of foaming on agitation, ſeems to give it a relation to mucous ſubſtances; but it differs from ani-

mal mucilages by not being convertible into a jelly, and not combining with tan; befides, the ammonia, the pruffic acid, and the empyreumatic oil, prevent it's being looked upon as a vegetable mucilage. Expofed to the fire, it fwells very much, emits at firft an odour like burnt mucilage, afterward that of an empyreumatic and ammoniacal oil; laftly, the odour of pruffic acid is ftrongly perceived. After inflammation, it leaves a very voluminous coal, eafily incinerated; the afhes are very light and of a beautiful white colour; are foluble in acids without effervefcence, and formed of phofphat of magnefia, and a very fmall quantity of phofphat of lime This animal matter is decompofed by the nitric acid, but it does not form (at leaft in any obfervable quantity) any vegetable acid, which is the cafe with the greater part of fubftances belonging to the organic kingdom; during it's action, carbonic acid and azot gafes are formed, mixed with nitrous gas.

Compofition.

Such are the principal facts relative to the principles contained in the liquor amnii, the formation of which is at prefent unknown.

Haller's Phyfiol.—Differtatio Chem.—Phyfiolog. de Natura & Utilitate Liquoris Amnii à Hubertus Van den Bofch. p. 54. Utrecht, 1792.—Extrait d'une Mémoire fur l'eau de l'amnios de femme et de vache, par les Cits. Buniva et Vauquelin. An. de Ch. No. 99. p. 269. 1799.

SOLIDS.

Although the folids may be faid to form the greateft part of the animal body, their component parts are much lefs known, and their analyfis much lefs advanced than that of the fluids, or perhaps of any other parts that have yet been fubmitted to chemical inveftigation. They have been divided by authors into red and white parts; amongft the firft, the mufcles or flefh and the liver have as yet only been examined; the fecond divifion comprehends the brain, fkin, the cartilages, tendons, ligaments, cellular membranes, the aponeurofis, and periofteum.

Their divifion into red and white.

1. Red parts. Thefe derive their colour from the red particles of the blood, which circulate in their veffels; whilft in animals, in which the red particles are not permitted to circulate, the mufcular parts are of a white colour, as is the cafe in the generality of fifhes, &c.

MUSCLE OR FLESH.

Neumann, who fubmitted different kinds of flefh to diftillation on the open fire, obtained from them the common products of animal fubftances, *i. e.* more or lefs of what he called an urinous fpirit, volatile falt, and an empyreumatic oil; whilft the black coal remaining behind afforded a fixed falt.

Mufcle examined by Neumann.

He was of opinion, that the nutritious matter of animal flefh is a fubftance of the gelatinous kind, and that water, by long boiling, diffolves and extracts it much more readily and completely from fome forts of flefh

than from others. This author gives us the method of making portable ſoup; as he informs us, that if the coction be performed in cloſe veſſels, and the liquor properly evaporated to a due conſiſtence, a ſolid extract may be obtained, which is a very ſerviceable preparation, for when thoroughly dried it keeps well, and may be again diſſolved by warm water into a liquor reſembling the ſoup or freſh decoction.

Geoffroy. According to the experiments of Geoffroy on a pound of the fleſh of the ox, ſheep, and calf, it appears, that the fleſh of the firſt affords the leaſt ſoluble ſubſtance, and that the proportion of the extract and fibrous part inſoluble in water, as well as of the humidity contained in them, is the following:

	Ox.			Sheep.			Calf.		
	oz.	drs.	grs.	oz.	drs.	grs.	oz.	drs.	grs.
Solid extract -		7	8	1	3	16	1	1	47
Humidity or phlegm	11	6	64	11	5	32	11	6	44
Dry fibres - -	3	2	o	2	7	24	2	7	32
	16 oz 1 lb.			Do.			Do.		

The muſcles of animals are compoſed of a parenchymatous and a cellular part, in which different humours are contained, partly in a concrete, and partly in a fluid ſtate. Theſe humours conſiſt, 1. Of a red and white albuminous fluid. 2. Of a gelatinous mucilage. 3. Of a mild oil of the nature of fat. 4. Of a peculiar extractive ſubſtance. 5. Of a ſaline matter, the nature of which is very little known.

The analyſis of the whole ſubſtance of the fleſh, which affords, by diſtillation on the water bath, a vapid water, an alkaline phlegm, an empyreumatic oil, and carbonat of ammonia, and which leaves a coal from which a little fixed alkali and muriat of potaſh or ſoda may be extracted by incineration, affords no exact knowledge of the nature of the different principles; hence it is neceſſary

to have recourſe to means, by which theſe ſubſtances may be extracted without obliging them to undergo a change of compoſition, and which afford an opportunity of examining them ſeparately.

To obtain and ſeparate theſe different ſubſtances, Thouvenel made uſe of a preſs by which the fluid parts were ſqueezed out of the muſcle; he then employed the action of fire to coagulate the albuminous part, and obtained the ſalt by evaporation; of water, to diſſolve and ſeparate the gelatinous mucilage, the ſalt, and extract; and of alcohol, to get the two laſt principles without the jelly. It is, however, very difficult to ſeparate all theſe different matters exactly, as they are all ſoluble in water, and becauſe the alcohol diſſolves at the ſame time the ſaponaceous extract and a part of the ſalt. Fourcroy has therefore given a different proceſs. Thouvenel.

Thouvenel found, from his experiments upon different ſorts of fleſh, that,

1ſt. The *fleſh* of the *ox* contained about three times it's weight of water and $\frac{1}{6}$ of dry extract, which on deducting the water, gives a proportion of one to four between the extractive matter and parenchymatous ſpunge; but for this concluſion it is neceſſary to exhauſt the fleſh by repeated decoctions, for in the ordinary preparations of this kind, ſcarcely the half of this product is obtained, ſince water diſſolves a leſs quantity of the mucous matter of the parenchyma; ſo that one pound of fleſh boiled four or five hours in twelve ounces of water affords commonly five or ſix drachms of dry reſiduum, *i. e.* dried as much as poſſible by a heat that is gentle and incapable of changing it's texture. Fleſh of the ox.

2d. The fleſh of the *calf* is more aqueous and mucous than that of the ox. The large quantity of reſidue from it's evaporated decoction ariſes principally from it's parenchyma being more ſoluble in water. It is the Calf.

ſame in all young animals. The chicken gives more extract than the cock. They alſo give more than the ox and calf. But this ariſes in part from the bones of the firſt being admitted into theſe decoctions, as it is well known theſe ſubſtances give up to water a larger quantity of mucous matter than the fibrous part; thus ſtag's horn gives more than one fourth of it's weight; bone of the ox ſomewhat leſs, being older, more compact, and charged with oſſeous earth.

Turtle. 3d. The *land* and *water* turtles contain a little more matter ſoluble in water than the fleſh of the ox or calf, but this ariſes from the oſſeous, cartilaginous, and ligamentous parts forming a part in the common preparation of boiled turtles; hence, Thouvenel found that one pound of turtle uſed in the common way, and exhauſted by repeated decoctions, afforded more than ten drachms of reſidue, whilſt the pure fleſh gave ſcarcely one ounce in the pound; but the decoction placed on the baln. mar. for four hours, as is commonly done, gives a ſtill leſs product; ſo that eight ounces of turtle in 20 ounces of water afforded 24 ounces of broth, and the grounds being expreſſed, half an ounce of dry extract was got by evaporation. Hence common broths from turtle only contain two drachms of mucous reſidue, whilſt thoſe from veal, chicken, and mutton, contain at leaſt from five to ſix drachms.

Snail. 4th. *Snails*, ſeparated from their ſhell by means of warm water, afford on decoction with an equal quantity of water on a baln. mar. about two drachms of extract leſs in the pound than the turtle, which places them nearly in the proportion of the before mentioned fleſh, or between the ox and calf, with reſpect to the quantity of ſoluble matter.

Frogs, &c. 5. *Frogs*, *crawfiſh*, and *vipers*, deprived of their envelops, inteſtines, and extremities, and then chopped, af-

ford, on being exhausted by decoction, nearly the same quantity of extractive matter as the other animals; *i. e.* about $\frac{1}{6}$ of their weight. But this proportion is not the same in the common preparation of these broths, for these last only then afford 4 or $4\frac{1}{2}$ drachms of residue per pound.

6th. The texture of *fish* being in general more tender and less fibrous than that of land animals, they ought to afford by decoction a greater quantity of soluble matter than the second. Experience, however, proves the contrary, at least with respect to fresh water fish, those of salt water affording more. This difference, according to Thouvenel, arises principally from the more or less glairy state, and the more or less concrescibility of the mucus of all aquatic animals, which causes their parenchyma to be more difficultly exhausted on decoction, and the extract more difficult to exsiccate, being more glutinous and gluey; and lastly, this dried glue to be more insoluble in water. Fish.

Such is the manner in which Thouvenel has examined the muscular substance of different animals, a memoir of which got the prize of the Academy of Bordeaux in 1778.

The process, which according to Fourcroy succeeds the best, is first to wash the flesh in cold water, which takes away the colouring part with a portion of the salt; then to digest the residuum of this lotion in alcohol, which dissolves the extractive matter and a portion of the salt; afterward, the flesh thus treated is to be boiled in water, which dissolves the gelatinous part and takes up, likewise, the portions of extract and of salt that had escaped the action of the former menstrua. The first water which was employed cold, is then to be gently evaporated, the albuminous part coagulates and is separated by the filter, and the slow evaporation of the fil- Fourcroy's experiments and observations.

tered liquor affords the faline matter. By evaporating the alcohol in the fame manner, the colouring extractive matter is obtained; and the decoction furnifhes the jelly and the fat oil which fwims upon it's furface, and becomes concrete on cooling. After the extraction of the different fubftances, there remains nothing but the fibrous part, which is white, infipid, and infoluble in water; on burning it contracts; affords much ammonia, and a very fetid oil by diftillation; and a large quantity of azot gas is expelled from it by the nitric acid; hence, it has all the characters of the fibrous part of the blood or of fibrin. To have a perfect knowledge, therefore, of the nature of the flefh of animals, it only remains to examine the properties of each of the fubftances of which it is compofed.

The albuminous part is fimilar to that of the blood, and it is this matter which, on coagulating by the heat of the water in which meat is boiled, produces the fcum which is carefully taken off. This fcum is of a dirty brown red colour, the red being changed by the heat of ebullition. The gelatin which is extracted is the caufe of the flefh of young animals, after having been boiled and become cool, taking the form of a tremulous mafs or jelly, as it contains a larger proportion of this principle than the flefh of old animals; it is common gelatin. The oil which forms itfelf into flat and circular drops, fwims upon the furface of boiled meat foups, and becomes folid or concrete on cooling, is fimilar to other animal oils. Thefe three parts are confequently well known, and there only remains to examine the extractive matter, and the falts which are alfo obtained in the analyfis of the mufcles.

The fubftance called by Thouvenel *mucous extractive matter*, is foluble in water and in alcohol, it has an evident favour which jelly has not. In a concentrated ftate

it has an acid and bitter tafte, and a peculiar aromatic odour which the fire develops; it is this matter that colours broths and gives them their agreeable favour and odour. When they are too much evaporated, or a large quantity of meat is boiled in a fmall qnantity of water, it is this that gives them their more or lefs ftrong and fomewhat acrid tafte and deep colour; laftly, the action of the fire extricates and heightens the favour of this extractive matter even fo as to give it the tafte of fugar or barley fugar, as is obferved on the furface of roaft meat, which is commonly called the *brown*. If the properties of this extractive matter be examined when evaporated to a dry confiftence, it's favour is found auftere, bitter, and faline; placed on a live coal, it fwells and liquifies, exhaling a penetrating acid odour, refembling that of burnt fugar; expofed to the air it becomes deliquefcent, and a faline efflorefcence takes place on it's furface; it becomes four, and putrefies on expofure to a warm air, if diluted with a certain quantity of water; and laftly, it is foluble in alcohol. All thefe characters appear to Fourcroy to prove, that this fubftance has a near relation to the foapy extracts and the faccharine matter of vegetables.

Since this chemift gave his opinion of the nature of this fubftance, Berthollet has difcovered a peculiar acid in animal fubftances, which appears to form the characters of the matter in queftion, for according to Berthollet, this acid which he calls the zoonic acid, (*vide* acids) has an odour which refembles that of flefh whilft roafting, and it has an auftere tafte.

As to the falt which cryftallizes during the flow evaporation of the decoction of flefh, it's nature at prefent is but imperfectly underftood.

Thouvenel obtained it in the form of down or of deformed cryftals. He took it to be a neutral falt formed

of potafh , and an acid refembling the phofphoric acid in frugivorous quadrupeds, and muriatic acid in carnivorous reptiles. Although this falt may be looked upon as unknown until further examined, Fourcroy thinks it very probable that it is the phofphat of foda and ammonia, and that there is even a mixture of phofphat of lime, as thefe falts are indicated, and even with an excefs of acid, as is the cafe in urine, by means of lime water and ammonia, which form white precipitates on being added to broths, and by the nitric folution of mercury, which produces a rofe coloured precipitate.

To thefe parts may be added that which is the moft abundant in mufcular flefh, and which conftitutes it's real character, viz. the fibrous part, the characters of which are: 1ft, to be infoluble in water; 2d, to afford more azot gas by the nitric acid than any other fubftance, and to give afterward the oxalic and malic acids; 3d, to putrefy eafily when moiftened, and afford on diftillation a large quantity of carbonat of ammonia. It is the fame as that of the blood. From this fact, Fourcroy is of opinion, that the mufcular organ is the refervoir in which the action of the vital powers depofits the fibrous matter of the blood, which, as before obferved, contains it in large quantity, and that by repofe it there becomes concrete, forming the bafis of that animal property called mufcular irritability.

Fourcroy obtained, on diftilling four ounces of ox and calf's flefh on the baln. mar.

	Ox flefh.			Calf's flefh.		
	oz.	drs.	grs.	oz.	drs.	grs.
Of fluid	2	6	36	2	6	54
Dry refiduum	1	1	36	1	1	28
	4	0	0	4	0	0

	Ox flesh.			Calf's flesh.		
	oz.	drs.	grs.	oz.	grs.	drs.
Another portion gave out of watery extract. (a.)	0	1	56	0	2	30
A fluid transmitted in b.m.	2	6	36	2	6	54
Remaining phlegm	0	1	16	0	0	52
dry fibres (b.)	0	6	36	0	5	62
	4	0	0	4	0	0
(a.) Chemically examined gave of sal. volat.	0	1	2	0	1	12
Oil and spirit	0	0	38			
Carbon	0	0	6	0	1	0
Left	0	0	10	0	0	18
	0	1	56	0	2	30
(b.) Gave out of sal volat.	0	2	0	0	0	64
Spirit volat.	0	0	36	0	1	37
Carbon	0	1	40	0	2	18
Left	0	2	12	0	0	13
	0	6	36	0	5	12

Hatchett's experiments on beef.

Some experiments on the muscular fibre have been made by Hatchett, particularly upon that of *beef*. In order to separate the liquid albuminous part, or lymph, as much as possible, a quantity of lean muscle of ox beef was cut into small thin pieces, then macerated during fifteen days in cold water, and afterward subjected to pressure each day, when the water was changed. The weather was very cold, and the maceration continued to the end of the 15th day without any sign of putrescency.

The ſhreds of muſcle (amounting to about three pounds) were then boiled with about ſix quarts of water, during five hours; and the water being changed, the ſame was repeated every day during the courſe of three weeks; at the end of which, the water afforded only ſlight ſigns of gelatin, when infuſion of oak bark, or nitro-muriat of tin was added. After this, the fibrous part was well preſſed and dried by the heat of a water bath.

Some of the muſcular fibre thus prepared was ſteeped in nitric acid, diluted with three meaſures of water during fifteen days. The acid acquired a yellow tinge, and poſſeſſed all the properties of the nitric ſolutions of albumen.

The fibre which had been thus ſteeped in the acid was (when waſhed) diſſolved by boiling water, and by evaporation became a gelatinous maſs; which being again diſſolved in boiling water, was precipitated by infuſion of oak bark, and more ſlowly by nitro-muriat of tin, like albuminous ſubſtances when treated in a ſimilar manner. When the fibre which had been ſteeped in the acid was immerſed in ammonia, it was not completely diſſolved, but afforded a reſiduum. The greater part, however, was diſſolved, and formed a deep orange or yellowiſh brown ſolution, ſimilar in properties to that of albumen. (*vide* white of egg.) When boiled with lixivium of cauſtic potaſh, this muſcular fibre was completely diſſolved, ammonia was diſcharged, and animal ſoap formed; which being diluted with water, and ſaturated with muriatic acid, yielded a precipitate ſimilar to that obtained from animal ſoap, except that it ſooner became hard and ſoapy when expoſed to the air.

Muſcular fibre prepared by long maceration, and ſubſequent boiling, with frequent change of water, ſo as to be nearly deprived of all it's gelatinous part, is not eaſily

brought into the putrid ſtate. A ſmall quantity was kept moiſtened with water during April, in the courſe of which time it acquired a muſty but not a putrid ſmell, neither were the fibres reduced to a pulpy maſs; a portion of it was kept two months under water, but it neither became putrid nor was converted into that fatty ſubſtance obtained from recent muſcle. Hence Hatchett is of opinion, that the readineſs with which muſcle becomes putrid is principally owing to the gelatin, which is mixed with it in large proportion, and which, with the natural quantity of moiſture, is requiſite to give the fibre a proper degree of toughneſs and flexibility.

The reſiduum afforded by muſcular fibre which had been long ſteeped in dilute nitric acid, and afterward immerſed in ammonia, conſiſted principally of fat, mixed with a ſmall portion of the fibre which had not been ſufficiently acted upon by the acid, and little or no earthy matter was thus obtained. But when the prepared muſcular fibre was diſſolved in boiling nitric acid, a complete ſolution reſembling that of albumen in it's general properties was formed, and ſome fat floated in drops at the top of the liquor. Ammonia was then added, ſo as to ſuperſaturate the acid, and produced the ſame effects as on the nitric ſolutions of albumen, excepting that a copious white precipitate was obtained. This precipitate, while moiſt, was agitated with a quantity of acetous acid, which diſſolved and ſeparated a ſmall portion of phoſphat of lime; but the remainder, and by much the greateſt part of this precipitate was ſcarcely attacked, even when the acid was boiled.

When expoſed to a red heat, it became dark gray, and then nearly white; after which it was in the ſtate of carbonat of lime.

Another part was diſſolved in nitric acid, and lime was precipitated by carbonat of ſoda. The ſlight exceſs of

the latter was then ſaturated by acetous acid, and the whole was boiled to expel the carbonic acid; after which the liquor from it's effects on ſolutions of lime, barytes, &c. evidently contained oxalic acid in ſolution; the precipitate was therefore oxalat of lime mixed with a very ſmall quantity of phoſphat of lime; 200 grains of the dry muſcular fibre, diſſolved and boiled with nitric acid, afforded 17 grains of this precipitate.

Although it is known that the gelatinous liquor obtained from muſcle by boiling water, contains phoſphats of ſoda and of lime; yet Hatchett did not imagine the greater part of the latter could be ſo completely ſeparated. He, therefore, in ſome meaſure, repeated the experiment on

Veal.

the *muſcle of veal*, and found phoſphats of ſoda and of lime in the liquor. But when the muſcle was afterward diſſolved in boiling nitric acid, and the ſolution ſaturated with ammonia; he was ſurpriſed to find that although the ſame change in colour was produced as in all the former experiments, the liquor remained tranſparent, and even after ſeveral days, only a few ſcattered particles appeared at the bottom of the veſſel.

Another experiment was made on the recent muſcle of

Mutton.

mutton, but this was immediately diſſolved in nitric acid, without being previouſly boiled in water. The fat being ſeparated, the ſolution was as before ſaturated with ammonia, and as uſual became of a deep orange colour, or yellowiſh brown; in a few hours alſo, a ſmall quantity of a white precipitate ſubſided. This precipitate, however, was completely and readily ſoluble in acetous acid, and in every reſpect proved to be phoſphat of lime.

This chemiſt obſerves, that the liquor from which the above precipitate was ſeparated, as well as thoſe afforded by the muſcle of veal, by the prepared muſcle of beef (as well as by the ſolutions of tortoiſeſhell and albumen) in boiling nitric acid, ſubſequently ſaturated with ammonia,

all contained a confiderable portion of uncombined oxalic acid, which was feparated by acetite of lime and of lead. But he did not find oxalic acid in the folutions formed by immerfing the bodies, for a long time, in cold and dilute nitric acid; neither did he find oxalic acid in folutions made by diffolving the fubftances in boiling muriatic acid. It is evident, therefore, that the oxalic acid obferved in the above experiments was a product of the operations, and not an educt of the fubftances.

Hatchett concludes from the experiments upon the above mufcular fubftances, that they contain lime in various proportions, and in two different ftates, viz. carbonat and phofphat, and that the greater part of the latter is gradually feparated, in conjunction with the gelatin, by means of boiling water. Not that phofphat of lime is an effential ingredient in gelatinous fubftances, on the contrary, ifinglafs, which is a perfectly gelatinous body, affords but a mere vifible trace of it. The mufcular fibre of beef appears to have been nearly deprived of it's phofphat of lime, by the long-continued and repeated boiling in water to which it had been fubjected; but ftill fo large a quantity of lime remained, that when oxalic acid was formed by the action of the boiling nitric acid, it combined with the lime and formed an oxalat amounting to 19 grains from 200 grains of the dry mufcular fibre, diffolved in nitric acid, and precipitated by ammonia. He does not know what quantity of lime was feparated with the gelatin; but from the quantity of lime remaining, and which afterward combined with the oxalic acid, the mufcle of beef muft contain a confiderable portion of earthy matter; and as by the experiment on the mufcle of veal, fcarcely any precipitate was obtained after it had been boiled, and as but a fmall portion of phofphat of lime was prefent in the gelatinous liquid, it appears, that in this mufcle, the whole of the fmall portion of

His conclufions.

lime it contained was in the ſtate of phoſphat; and this being nearly ſeparated, there did not remain any part of uncombined lime or carbonat of lime, which by uniting with the oxalic acid (ſubſequently produced) would form an oxalat; and as lime in the ſtates of phoſphat and carbonat is ſo much more abundant in the muſcle of beef than in that of veal, it may be inferred that the earthy matter is more abundant in the coarſe and rigid fibre of adult and aged animals, than in the tender fibre of young ones; and this ſeems to be corroborated by the tendency to morbid oſſification, ſo frequently obſerved in aged individuals of the human ſpecies. Five hundred grains of the dry prepared muſcular fibre of beef, when diſtilled, left 108 grains of coal, which, by incineration, afforded 25,60 grains of earthy reſiduum; the coal may therefore be eſtimated at 82,40 grains. The greateſt part of theſe 25,60 grains was carbonat of lime mixed with ſome pure lime and a ſmall portion of phoſphat, and there can be no doubt but that the latter would have been more abundant, had it not been for the repeated boilings to which the muſcular fibre had been ſubjected.

The recent muſcles of veal and mutton were, with great difficulty, reduced to aſhes; for toward the end of the proceſs, the aſhes and remaining coal became coated and glazed with ſaline matter, which appeared to be ſoda, partly in the ſtate of phoſphat.

Component parts of fleſh.

It appears, therefore, from the experiments already mentioned, that muſcle or fleſh conſiſts of albumen, gelatin, fibrin, the phoſphats of ſoda and of lime, muriat of ſoda, the zoonic acid, and iron; but a more exact analyſis is neceſſary to aſcertain it's component parts with preciſion and certainty.

LIVER.

Liver of the ſkate examined by Vauquelin.

The human liver has been examined by Fourcroy, but it was in a ſtate of decompoſition or putrefaction. Vauquelin, who has already rendered himſelf ſo highly eminent in the analyſis of animal ſubſtances, has given a detailed account of that of the liver of the ſkate.

It is well known to anatomiſts, that the liver of this fiſh (raya batis, L.) is very voluminous when compared to the other viſcera, ſuch as the heart and lungs, that it's ſtructure and texture are very delicate and tender, and that externally it's appearance is fatty and oleaginous. It is of a gray colour, and when freſh has a roſy tinge, but this varies in different livers. It's ſavour is ſaline and oily; it's odour reſembles that of mud, and is ſomewhat analogous to what ariſes from the filth of fiſh-markets. When boiled in water, it produces a great quantity of oil, which remains fluid at the ordinary temperature of the atmoſphere. A piece of this liver produced by expreſſion, after boiling, a ſlightly yellow coloured oil, that remained liquid at 10°.—When triturated with cold water in a mortar, it formed a white emulſion reſembling milk, and in a few hours Vauquelin obſerved, that a yellowiſh cream aroſe to the ſurface, which appears to have been a portion of oil with a ſmall part of the parenchyma. This emulſion was decompoſed by the weakeſt acids, and ſmall grumous parts ſeparated from the clear liquor and aroſe to the top, as takes place in the decompoſition of ſoaps by acids. This cream, on being agitated ſome time in a marble mortar, afforded no butter, but an oil much thinner than that extracted by heat. The parenchymatous and albuminous parts, which were coagulated, became brown in the air. The ſolution changed paper coloured by mallows to a green, which

this chemiſt attributes to an incipient putrefaction. Four ounces of this liquor bruiſed, and expoſed to a gentle heat till no more vapours aroſe, afforded by expreſſion one drachm ſeven grains of oil, the remainder weighed four drachms thirty-ſix grains; this laſt quantity of parenchyma, when incinerated, gave eight grains of a ſemi-fuſed white matter, which adhered ſlightly to the ſides of the crucible. On adding muriatic acid to this matter, a ſulphureous vapour was diſengaged, and the liquor ſoon changed to a ſlight yellow colour, but there was no effervescence on the addition of lime-water; it appeared from the precipitation, that the aſhes contained phoſphat of lime.

Oxygenated muriatic acid being poured upon two drachms of this oil, until it ceaſed to give an odour, *i. e.* until ſaturated with oxygen and not decompoſed, the oil became white as fat, and of the conſiſtence of wax that has been kept between the fingers for ſome time. Theſe experiments prove, according to this chemiſt, that the liver of the ray contains more than half it's weight of oil already formed, and as to the concluſion to be drawn from it, *vide* article BILE.

Elémens d'Hiſtoire Naturelle et de Chemie, 4. edit. par M. Fourcroy. t. 4. p. 431. 1791.—Encyc. Méth. Méd. t. 4. p. 573. chair des animaux.—Examen Chimique du Foie de Raie, par M. Vauquelin. An. de Ch. tom. 10. p. 193.—Hatchett's Expts. Phil. Tranſ. 1800.

WHITE PARTS.

BRAIN.

THE opinions with refpect to the compofition of this organ have been chiefly confined to it's fuppofed oily nature, whilft others have denied it to poffefs any fuch property. Plato compared the brain to marrow, becaufe like that fubftance it is foft and enclofed in an offeous envelop. Hippocrates, on the contrary, would not allow it to contain any thing that refembled fat. Ariftotle was of opinion, that it was of a fatty nature in man and quadrupeds, and in the cetaceous clafs he had no doubt of it. This was again denied by more modern writers, and again afferted by Bartholin and Diemerbroeck; and as a proof in it's favour, they announced it's fatty touch, and it's inclination to liquefy or melt rather than run. Lewenhoeck, on examining the cortical part of the brain of a bird, thought it was formed of fmall veffels, and of a fpecies of vitreous humour fimilar to fat. Afterward, chemical analyfis came to fupport that opinion, and Lemery in particular, on fubmitting the brain to diftillation, obtained a large quantity of limpid phlegm, volatile alkali, and two kinds of oil; the one yellow, and of the confiftence of butter; the other black, fetid, and as thick as pitch. Burrhus alfo examined it, and on fubmitting it to the action of a hot prefs, after having fqueezed out about three-fourths of it's weight of an inodorous phlegm, extracted a very inflammable oil from it, which on cooling fuddenly, took a concrete form. Thouret has fince made fome experiments on this organ; for although it was known to poffefs oily properties, not only from

Brain.

Ancient opinions.

what has been already mentioned, but from it's having been found perfectly preferved for even fifty or eighty years from putrefaction, appearing like a fat or oily fluid matter, as we are informed by Faber and Herbinius; and although the folubility of the brain in aqueous fluids was known to anatomifts, yet it's foapy character, or that it's oil was rendered mifcible with water by means of an alkaline fubftance, was not even conjectured, until the experiments of this chemift pointed it out. It is from

Examined by Thouret.

thefe Thouret concludes that the fubftance of the brain refembles that of the fingular fpecies of foap into which the greater part of the bodies was found to be transformed in the cemetery of the Innocents at Paris. It is like this laft, formed of a more or lefs concrete and cryftallized oily matter, very fufible, foluble in fpirit of wine, and forming a fpecies of real foap; and the only difference between them is, that in the bodies of the Innocents the oil is united with volatile alkali, whilft in the brain, potafh is the alkaline fubftance; and he concludes, that it is from this oily or foapy nature, which appears to refemble fpermaceti, that this organ is found to be fo little fufceptible of decompofition in the earth, provided it does not meet with any great degree of humidity, and that it is enabled to exift fo long after all the other foft parts of the body are entirely decayed.

Fourcroy.

The experiments of Fourcroy appear to lead to a conclufion very different from thofe of the laft mentioned chemift, they were made upon the frefh brains of the calf, the fheep, and the human animal, deprived of their fanguiferous veffels and membranes, interpofed between the circumvolutions. Thefe brains on being left to themfelves for feveral days, at a temperature of twelve degrees, exhaled a very difagreeable odour, and fenfibly changed blue paper green; and this before the production of any ammonia, although the green colour and detefta-

ble odour would feem to indicate an alkalefcency. It partakes of this property with all other animal fubftances that contain mucilage, gelatin, or any white fibres fufceptible of paffing into the fame ftate by the action of heat. Some dried brain, on being boiled with alcohol, formed a fort of glutinous pafte, of a deep colour, ductile, and when preffed by the fingers, capable of being lengthened all ways. It does not melt in the heat of boiling water, but only becomes fofter; when expofed to a higher temperature, it appears inclined to liquefy, it's colour becomes deeper, and of a darkifh yellow; there arifes an empyreumatic ammoniacal fmoke, and the heat is increafed; there remaining only a coal.

Fourcroy obferves, that it is this fubftance that Thouret has not hefitated to compare to fpermaceti, to the adipocerous matter of the bodies of the Innocents, and to the concrete oil extracted from biliary calculi by alcohol. Thefe three fubftances have, however, no fimilarity with it in the eyes of the experienced chemift; for it is well known that a degree of heat from 30° to 32°, is fufficient to melt fpermaceti and the adipocerous fubftance. As to the concrete biliary matter, it requires fome degrees above boiling water to become fluid, and it does not emit during it's paffage to that ftate any empyreumatic or ammoniacal vapour like that of the brain. Thefe matters this chemift contends have therefore no refemblance, except a tendency to take a regular form on becoming fixed, and he looks upon this matter to be a fubftance *fui generis*, which differs from all other animal fubftances in the proportions of it's principles. Thouret relates, that Burrhus had expreffed an oil from dried brain, concrefcible by cold, which he compared to fpermaceti; but Fourcroy is of opinion, that by the ordinary means employed to extract oils and fats, contained naturally in animal as well as vegetable fubftances, it is not to be got

from the brain, and that it is only by changing it's principles that ſome chemiſts have been able to obtain it. From the analyſis of this organ, Fourcroy concludes, that beſides this animal pulp *ſui generis*, the brain is compoſed of the phoſphats of ammonia, of lime, and of ſoda; that each is only in ſmall proportion, that it contains no free alkali, and not an atom of potaſh, although admitted to exiſt in it by Thouret, and that of all animal ſubſtances the brain approaches the moſt in it's nature to that of the albumen of the blood.

Compoſition of the brain.

Mémoire ſur la Nature de la Subſtance du Cerveau, &c. par M. Thouret. Journal de Phyſique. Mai. p. 329, 1791.—Examen Chimique du Cerveau de pluſieurs animaux, par A. F. Fourcroy, Annales de Chimie. tom. 16. p. 282.

SKIN.

Of the ſkins or hides of animals, there has only been a ſlight examination of the epidermis of the human ſkin. According to Chaptal, the human epidermis is the moſt eaſily detached from the cutis of any, and it may be effected by the heat of water. The cutis then reſembles ſoftened cartilage in conſiſtence. On continuing the boiling the ſkin is diſſolved, but the hot water has no action on the epidermis. Skin. Examined by Chaptal.

Dilute nitric acid, according to Hatchett, has the ſame effect.

The epidermis is ſoluble in cauſtic alkalis; and by lime, although more ſlowly.

Alcohol digeſted a long time upon it with heat produced no effect.

From theſe circumſtances Chaptal concludes, that there is ſome analogy between the exterior envelop of the human body, and that which acts as a cover to ſilk; and he draws ſome conſequences that may be applied to the operations of tanning, thus:

1ſt. If a hide covered with it's epidermis be plunged into an infuſion of tan, this laſt can only penetrate by the fleſhy ſide, the other being defended from it by the epidermis which is not ſuſceptible of any combination with the tanning principle.

2d. When the epidermis has been taken off by the operation of depriving it of the hair, the tan is able to penetrate by both ſurfaces of the ſkin.

3d. The lime generally employed to take off the hair appears to act only by diſſolving the epidermis. He found lime-water to have a ſtronger action than lime

undiſſolved, but that it's effect ceaſed the moment the ſmall quantity of lime held in ſolution became combined; hence, the neceſſity of renewing the lime-water to finiſh the operation.

Seguin on tanning.

For the diſcovery of the true principles upon which the art of tanning hides is founded, we are indebted to Seguin. Before the inveſtigation of this chemiſt, it was generally ſuppoſed that the tan in the tan pits had no other effect on the hides, than to harden and brace the fibres of the ſkin which had been relaxed by the preliminary operations; but the experiments of Seguin prove, that there exiſts in the tan a principle that is ſoluble in water, by which the tanning is effected; that this principle becomes afterward fixed in the hide in conſequence of a particular combination between this principle and the ſkin, and that this combination produces a ſubſtance inſoluble in water.

It is well known that if untanned leather be boiled in water it is ſoon diſſolved by it, and this ſolution by being concentrated produces a jelly or ſize, which, by further evaporation and exſiccation in the air, becomes what is called glue.

Explanation of the proceſs.

On examining the effect of a ſolution of tan upon a ſolution of glue, they are ſcarcely mixed before a white filamentous precipitate takes place, ariſing from the union of the gelatin with the tanning principle. This precipitate is inſoluble both in hot and cold water, and acquires colour on expoſure to light. This is the real explanation of the proceſs of tanning. The ſolution of tan therefore acts upon the hides (from which glue is produced) in the ſame manner as it acts upon glue, and is what happens both in common tan pits and in the new method of tanning by Seguin, in both of which the ſolution of tan gradually penetrates the hide and combines with it, producing a gradual change of colour till the

hide is changed throughout, becoming of a marbled appearance refembling a nutmeg, and of a compact texture. From this it appears, that a precipitation alfo takes place in the action of tanning, although the hide is not diffolved, but merely fwelled, fo as to enable the folution of tan to penetrate it more eafily.

This property which animal glue or gelatin has of being precipitated by a folution of the tanning principle, affords a method of difcovering what fubftances may be ufeful in tanning. Nothing more is neceffary than to make a folution or infufion of the vegetable fubftance, and this when mixed with a folution of glue will fhow whether it can be employed with advantage in tanning, by the greater or lefs quantity of precipitate produced.

Lime-water, likewife, according to the fame chemift, offers an excellent means of difcovering fuch fubftances. If, for inftance, lime-water be added to a folution of tan, the mixture inftantly produces a copious precipitate; and if a fufficient quantity of lime-water be added to neutralize the whole quantity of the tanning principle, the fupernatant liquor, ftill coloured, will not form any precipitate with a folution of glue. In like manner, the liquor feparated from a precipitation by the mixture of a folution of tan with one of glue, will not produce any precipitate with lime-water, if during the precipitation the tanning principle has been completely neutralized. This fhows that Macbride's method of extracting tan by means of lime-water is defective; and that a lofs of the tanning principle, takes place, in proportion to the quantity of it combined with the lime diffolved in the lime-water.

From the preceding account of the action of glue or of lime water upon a folution of tan, it follows, that every vegetable infufion, which affords a precipitate upon the addition of either of thefe reagents, muft contain in a greater or lefs proportion the tanning principle. A decoction of Peruvian bark, for inftance, when mixed with

lime-water, gives a precipitate which arifes from the union of the lime and the tanning principle of the bark.

Tanning matter.

The tanning principle appears to be a fubftance of a peculiar nature, which exifts in aftringent vegetables, and is not, as has been fuppofed, that acid called the gallic acid difcovered by Scheele in galls, and found likewife in aftringent vegetables, and faid to have fome effect in tanning. To the difcovery of this tanning matter which Seguin found to be foluble in water, and which by uniting with the gelatin of the fkin renders it an infoluble compound; it may be added, that when the water has extracted all the tanning matter from the tan, even to faturation, and has given it up to the gelatin of the hide; the fame water may be ufed to extract more of the fame matter from frefh tan; this facilitates the carriage of the tanning matter by reducing it to a fmall volume, or it may be converted into an extract. According to Prouft, the aqueous folution of tan poured on a folution of glue, produces a magma poffeffing the elaftic properties of the gluten of flour; that when left to itfelf it contracts, and on perfect exficcation is brown and refembles glafs in it's fracture; that it is incapable of putrefaction; perfectly foluble in water; yields very little to alcohol, and by the means of hot water is capable of recovering it's elaftic properties. He likewife found, that the tanning liquor caufes a precipitation in albuminous fluids, but the refult is not a magma capable of the fame tranfaction. Berthollet fufpects that tanning cannot take place without the action of air, *i. e.* in clofed veffels.

Having given fome account of the principles upon which the art of tanning is founded, it will not be deviating from the fubject to add a fhort defcription of the new chemical proceffes, which have been formed to accelerate the preparation of the fkins, and the combination of the tanning matter or principle.

Previous to the experiments of Seguin, the procefs of tanning was an operation of much time and trouble, even years were neceffary to bring the hide to a ftate of leather. The revolution this chemift has brought about in this art enables the tanner to complete his formerly arduous procefs in the fhort fpace of a few days, whilft the leather is fuperior in quality to that made after the old method.

New method of tanning according to Seguin.

The operations of this chemift confift, as in the former procefs of tanning, viz. in wafhing the hides, depriving them of the flefh and hair, raifing or fwelling them, and tanning properly fo called; but the modifications and alterations he has made in thefe proceffes are very different. To this may be added that he operated upon 110 hides of oxen, cows, calves, horfes, fheep, and goats, in the prefence of Lelievre and Pelletier.

1ft. *Wafhing and cleanfing the hides.* In this operation no alteration is made by Seguin; he does not however throw them promifcuoufly into water as fome tanners do, but ftretches or extends them fo as to permit the water to come into contact with every part. This precaution had already been recommended by others.

2d. *Taking off the hair.* With refpect to fhaving it off, which has always been looked upon as the moft expeditious way, from fome trials it was found by Seguin to be attended with difadvantages. Hides, it is well known, are covered with an epidermis, which is deftroyed by the method of depriving them of their hair by lime; but as it ftill remains after the procefs of fhaving, it is a great obftacle to the action of the tanning matter, by preventing it's folution from penetrating the hide on it's grain fide; hence, a longer time is required for the procefs of tanning.

With refpect to the employment of alkalis in taking it off, they are too expenfive for common practice.

With refpect to the method by means of lime, we are informed that fome lime was firft flacked; it was then put into a pit and mixed with a large proportion of water, and the whole was well ftirred that the water might be well faturated with the lime; the hides were then fufpended perpendicularly in the lime-water by ftrings attached to poles laid acrofs the pit, and as it loft it's ftrength, the lime at the bottom was often ftirred in order to keep the water ftill faturated. The hair came off with great eafe in this operation, after remaining about eight days in the pit.

By another method this chemift is in hopes of taking off the hair in two days. This confifts in plunging the hides after being wafhed and cleanfed in old tan water (which having been already ufed contains no tanning matter) mixed with a $\frac{5}{100}$ part, or fometimes with only $\frac{1}{1000}$ part of fulphuric acid. He found that pieces of hides thus treated were deprived of their hair with great eafe, and very completely raifed or fwelled. This chemift has fo much confidence in this procefs, that he informed Lelievre and Pelletier, in whofe prefence it was performed, he would adopt it in a tan yard in preference to any other.

He is likewife of opinion that another method of taking off the hair might be advantageoufly practifed in a tan yard, viz. by heat, produced by a ftove kept conftantly at 30° of Reaumur in which the hides are to be fufpended; and it is obferved by the above mentioned gentlemen, that if a little fulphur was burnt in the ftove, fo that the fulphureous acid gas arifing might be equally diffufed, it would greatly facilitate the procefs.

3d. *Swelling or raifing the hides.* For this purpofe large wooden tubs well joined together are filled with water, and a $\frac{1.5}{100}$ part of fulphuric acid added; into this mixture the hides are put, after having been previoufly well wafhed

and deprived of their hair. This quantity was decreafed to $\frac{1}{1000}$. The hides began to fwell after having remained a fhort time in this liquor, and in 48 hours the fwelling is completed. They now acquire a yellow colour even in the interior part of their fubftance. In this ftate, according to Seguin, the procefs of fwelling is finifhed: to determine this, one of the corners of the hide is to be cut, and if it be in a proper ftate, no white ftreak will appear in the middle; but through it's whole fubftance the hide will have acquired a yellow colour, and a femi-tranfparent appearance. This method, it may be obferved, is the fame as that of Macbride, except that the proportion of fulphuric acid is much diminifhed.

According, however, to Seguin, this operation of the fwelling of the hides may be difpenfed with, fince he has tanned them equally well without it; he even found the leather much lefs porous, and confequently lefs permeable to water.

4th. *Procefs of tanning according to Seguin.* Tanning, properly fo called, is performed by this chemift, after a particular method. He does not lay the hides in a pit as is ufually practifed, but tans them by means of a folution of tan which he prepares in the following manner: He places feveral rows of cafks upon ftands elevated fo much above the ground, that a veffel may be placed under each to receive the liquor which runs from them. Thefe cafks are filled with frefh tan; a certain quantity of water is then poured into the firft of them, which, as it runs through the tan, extracts the foluble part, and as faft as it runs into the veffel below is taken out and poured into the fecond cafk, and fo on fucceffively until the folution is fufficiently faturated; it may be brought to 10° or 12° of the areometer for falts. In order to exhauft the tan of the firft cafks, frefh water is poured upon it till it runs off perfectly clear, as the tan

is then completely deprived of it's ſoluble part. The liquors, as may be eaſily conceived, are carefully kept for future operations. It is propoſed by this chemiſt, to make uſe in a tan yard of large wooden vats, for the preparation of the ſolution of tan.

It is particularly in the uſe of this ſolution that the method of Seguin conſiſts. The quickneſs with which it acts is aſtoniſhing, and our ſurpriſe is excited that no perſon before him has attempted to put this method in practice in the large way.

As ſoon as the hides are taken out of the water impregnated with ſulphuric acid, they are to be put into a weak ſolution of tan, where they are to be left one or two hours; they are then to be plunged into other ſolutions, more or leſs charged with this principle according to their ſtrength, ſo that ſtrong hides are tanned in ſix or eight days, others in fifteen, and others in twenty or twenty-five days. In placing the hides in theſe ſolutions ſome precautions are neceſſary.

Seguin propoſes to have large vats which are to be filled with a ſolution of tan, the hides are then to be placed in them ſo as to be perpendicularly ſuſpended about one inch diſtant from each other, as their touching would impede the action of the ſolution.

The hides, when taken out of the ſolution, muſt be dried with the uſual precaution, *i. e.* ſo ſlowly as not to cauſe the hide to ſhrink on the fleſh ſide. With reſpect to thinner hides, for the upper leather of ſhoes, he begins by waſhing and taking off the fleſh in the manner deſcribed for ſtrong ſole leather; he then takes off the hair with clear lime-water; they do not undergo the operation of ſwelling, but are immediately put into weak ſolutions of tan, the ſtrength of which he gradually increaſes, but without ever being brought to that degree of concentration uſed for tanning thick leather. Two,

three, or four days, are fufficient for tanning this thinner leather.

Leather which has not been fufficiently impregnated with the tanning matter, is generally known by a white ftreak in the middle of it's fubftance. This, however, was not perceptible in the hides tanned by Seguin in the prefence of the above gentlemen. This method has likewife the advantage of affording an opportunity of examining from time to time the progrefs of the operation. For this purpofe, nothing is neceffary but to take a flip of the hide out of the vat, to cut off a corner of it, and the white ftreak, already mentioned, will appear more or lefs thick, until the tanning is completed.

Advantages of the new method.

The advantages of Seguin's method are, 1ft. *It is much fhorter*. The common method with lime requires, for ftrong fole leather, a year for the preliminary operations, and fometimes fifteen months more for the tanning operation in the pit. Sometimes it remains two years in the tan pits, it being pretended that the fuperiority of the leather is to be attributed to the great length of time the hides are left in them, fo that they even fometimes remain two years and a half to carry the procefs to the greateft perfection. The duration of Seguin's method is only about twenty days; in winter it is longer. 2d. *It is lefs laborious*. No manual labour is required, except in taking off the flefh and hair, for as foon as the hides are put into the folution of tan, they remain till the procefs is completed; whilft in the old way, there is a great deal of labour in taking them out of the pits, from time to time, to turn them. 3d. *It is lefs expenfive*. There is one thing here to be obferved; it is better only to prepare as much tanning folution as is neceffary for prefent ufe, as the above gentlemen thought they obferved a difpofition in the folutions of tan to pafs into the vinous fer-

mentation, which if the acetous ſhould follow before the ſolution is exhauſted, it would be an abſolute loſs of the tanning principle. Hence it is neceſſary to be watchful, eſpecially in ſummer. 4th. *It produces leather at leaſt of equal goodneſs.* To which may be added the important advantage of the extract of tan, which can be prepared in any foreſt on the ſpot, which from it's ſmall volume and weight, when compared to oak bark, may be carried away with the greateſt facility. It might be made in America, and tranſported to Europe, and alſo from other vegetables beſides the oak. When uſed, it is only neceſſary to rediſſolve it in a proper quantity of water.

Since the bark of trees contains two principles, viz. the tanning, and the aſtringent, or in other words, tanning matter and the gallic acid, both of which are applied to the hide in the proceſs of converting it into leather; it remained to inveſtigate, whether or not the gallic acid was hurtful or uſeful; and for this purpoſe, Biggin made ſome experiments upon different barks, to aſcertain the quantity of tan and gallic acid each bark contained, according to the proceſs of Seguin.

Biggin's experiments to aſcertain the quantity of tan.

His teſt to diſcover the tan, was a ſolution of one ounce of common glue in two pounds of boiling water, which conſequently contained the matter of ſkin, as he calls it, in ſolution; and for a teſt of the gallic acid, he uſed a ſaturated ſolution of ſulphat of iron.

For a preparation of bark, he divided one pound of each bark, in a pulverized ſtate, into five parts, which he put into five different earthen veſſels. To one part of this, he added two pounds of water, and infuſed them during one hour. This was then poured upon a ſecond part, and this again on the third, and ſo on to the fifth. But as a certain portion of the infuſion might remain attached to the *wood* of the bark, after decantation, he added a

third pound of water to the firſt part, and then followed up the infuſion on the ſeveral parts, till the three pounds of water, or as much of them as could be ſeparated from the bark, were united in the fifth veſſel, from which he generally obtained about one pint of ſtrong infuſion of bark.

To a certain quantity of this infuſion, he added a given meaſure of the ſolution of glue, which formed an immediate precipitation, to be ſeparated by filtering paper. This, when dried, is the powder of leather, formed by an union of the matter of ſkin with the tanning principle, and, by ſaturating the infuſion, the whole of the tan may be ſeparated by precipitation.

To procure the gallic acid, he added to the pound of bark left in the earthen veſſel, already deprived of the tan by theſe *quick* infuſions, a given quantity of water; but to get a ſtrong infuſion of this acid, a longer time (for inſtance 48 hours) is required. This infuſion, when obtained pure (it being ſcarcely poſſible to ſeparate them by this means, ſince a little of the acid always remains in the infuſion of tan, and vice verſa, unleſs the infuſion of the gallic acid is very weak, and procured by a third or fourth operation) gives very little ſigns of the preſence of tan, when tried by the ſolution of glue; but with the ſolution of ſulphat of iron, a ſtrong black colour is produced which differs in denſity according to the quality of the bark; and this may be further proved by boiling a ſkain of worſted in the dye, by which the gradations of colour may be perceptibly demonſtrated. The gallic acid.

Having thus obtained a point of compariſon, and ſtrictly attending to the ſpecific gravity of the infuſion, the quantity of precipitate of leather, and the denſity of colour produced by given quantities of one or the other teſt, the reſult will be found a comparative ſtatement of

the refpective powers of any bark or vegetable fubftance, which is fufficiently accurate for all commercial purpofes; and the quantity of tan contained in them, when compared with that in the oak bark, the ufual fubftance employed for the purpofe of tanning, will determine the commercial utility of the bark.

For an accurate chemical analyfis, he found the muriat of tin very convenient; for a folution of it being added to the infufion of bark, forms a precipitate with the tan, leaving the gallic acid fufpended. This precipitate is of a fawn colour, and is compofed of tan and oxydated tin. By thefe means, Biggin has been enabled to form a comparative fcale of barks, which, however, he allows to be imperfect. In the following fcale he has taken fumach as the moft powerful; leaving, at the fame time, a few degrees for a *fuppofed maximum of tanning principle*, which he reckons at 20.

Bark of the	Gallic acid by colour.	Tanning princ. by the hydrometer.	Tan. princ. (in grains) from half a pint of infufion, and 1 oz. of folution of glue.
Elm	7	2.1	28
Oak, cut in winter	8	2.1	30
Horfe chefnut	6	2.2	30
Beach	7	2.4	31
Willow (boughs)	8	2.4	31
Elder	4	3.0	41
Plum tree	8	4.0	58
Willow trunk	9	4.0	52
Sycamore	6	4.1	53
Birch	4	4.1	54
Cherry tree	8	4.2	59
Sallow	8	4.6	59

Mountain aſh	8	4.7	60
Poplar	9	6.0	76
Hazel	9	6.3	79
Aſh	10	6.6	82
Spaniſh cheſnut ..	10	9.0	98
Smooth oak	10	9.2	104
Oak, cut in ſpring	10	9.6	108
Huntingdon, or Leiceſter willow ...	10	10.1	109
Sumach	14	10.2	158

Biggin found that theſe barks preſerved no reſpective proportion in the quantity of gallic acid and tanning principle contained in each, which he looks upon as an evidence of the diſtinctneſs of them, and may perhaps open a new field of ſaving oak bark in dying, ſince the willow, ſallow, aſh, and others, produce a very fine black. The quantities, likewiſe, of theſe two principles, do not differ in equal proportions between the winter and ſpring felled oaks, which may lead to a diſcrimination of the proper time for cutting, which is probably when the ſap has completely filled and dilated that part of the vegetable intended for uſe. This will make a difference in the ſeaſon of cutting oak, elm, and other trees, ſhrubs, &c. The leaves ſhould be taken when at their full ſize, and then dried under cover; for as the tan is ſo ſoluble, and the ſubſtance that contains it, ſo thin, (the leaf) the dew is ſufficient to diſſolve it.

Finally, ſince the gallic acid does not ſeem to combine with the matter of ſkin, and as it's aſtringency will corrugate the ſurface, Biggin thinks it may be concluded, that it's preſence in the art of tanning is not only uſeleſs but detrimental.

Sur l'Epiderme par le Cit. Chaptal. Annal. de Ch,

No. 77. p. 221. Prouſt ſur le Principe Tannant. ibid. Mars, 1798, vol. 25, p. 228.—Account of the new Method of Tanning propoſed by Monſ. Seguin, by Meſſrs. Lelievre & Pelletier, Repertory of Arts, p. 272.—Vide alſo, Mémoire, Trouver le Moyen de rendre le Cuir impermeable à l'Eau ſans altérer ni ſa force, ni ſa ſoupleſſe, & ſans en augmenter ſenſiblement le prix. par le Cheval. de St. Real. Ann. de Chimie. tom. 10, p. 44.—Experiments to determine the quantity of tanning principle and gallic acid contained in the bark of various trees, by George Biggin, Eſq. Nich. Journal. No. 34, p. 392.

MEMBRANOUS, TENDINOUS, AND LIGAMENTOUS PARTS.

Their properties.

UNDER this head are to be comprehended all the fine membranes and cellular texture of the animal body; the white membranes that line the different cavities, as the pericardium, dura mater, pleura, &c. thofe that cover certain parts, as the periofteum, aponeurofis, &c. the different tendons that are attached to the mufcles, and all others of a fimilar nature; and the ligaments that unite the joints, together with all others of fimilar appearance.

Thefe, when fubmitted to chemical analyfis, appear to be all of a fimilar nature; but they have not at prefent been examined with fuch precifion as to point out any minute differences that may exift between them, and which might appear to arife from the proportions of their component parts. They are infoluble in cold water; but by a gentle heat and after a certain time, they produce an acidity, perceptible both by the fmell and tafte. They readily pafs to the putrid fermentation; but what characterizes them moft is, that when thefe white membranous, tendinous, and ligamentous parts are put into boiling water, or are fubmitted to a boiling heat, they foon become foft, lofe their texture, and are converted into a vifcous, clammy, more or lefs thick liquid, which, on becoming cool, takes the form of a clear jelly, and which is of great ufe in the arts under the name of *glue*. When expofed to a gentle heat, without the intervention of water, they become dry, lofe their toughnefs, are tranfparent, brittle, and eafily break with a fnapping between the fingers. By a ftronger heat, they curl up and are con-

tracted, and, on continuing the heat, they melt, produce a fetid difagreeable fmell, although not fo empyreumatic as the more animalized parts; they fwell and inflame, although the inflammation is fomewhat difficult. The coal which remains, is light, and eafily incinerated, whilft from their affording the ufual products of animal fubftances in a fmall degree, they may be looked upon as but flightly animalized.

GLUE.

Glue. At the article *Gelatin*, it is obferved, that it is particularly from the white parts of animals that fubftance is extracted; but as it was not intended, on difcuffing the nature of the component parts, to make any application of them to the arts, an account of the making of glue, and other circumftances attending it, were referved for the prefent.

Glue has nearly all the properties of gelatin; the difference, according to Fourcroy, confifting only in the confiftence. Gelatin has lefs vifcidity and tenacioufnefs, being more particularly obtained from young animals; whilft glue, on the contrary, is only obtained from old animals, whofe fibre is become drier and more ftrong.

Du Hamel. According to du Hamel du Monceau, who has written, perhaps, the beft work on the fubject; glue was firft principally prepared from a folution of the membranous, tendinous, and cartilaginous parts of animals; they were dried, and afterwards melted into tablets. It is, however, found, that all animal fubftances containing jelly, are capable of being made ufe of in the manufactory of glue; and du Hamel likewife informs us, that hartfhorn and bones, after having been diffolved in Papin's digefter, afforded a glue of great ftrength, but of a black colour.

That glue might be extracted from bones, we are in-

formed by Papin himſelf. In the edition of his works printed in 1782, it is ſaid, that, by means of his digeſter, he had not only prepared a jelly from bones, but alſo from ivory, with which he had glued together ſome pieces of broken glaſs; and from experiments that have been ſince made upon them, it appears they contain it in a conſiderable quantity. Papin.

Spielman has added a good deal of information to that found in Papin on this ſubject. According to this chemiſt, he has extracted glue, or dry jelly, not only from the bones, but all the hard parts of animals, ſimply by ebullition; that he procured more or leſs of it from the teeth of the wild boar, thoſe of the ſea horſe, and likewiſe from the wood-louſe, and the viper. Spielman.

There are ſeveral ſorts of glue made in Europe. The Engliſh glue is eſteemed the beſt; it is of a browniſh red colour. The Flanders is looked upon as next in point of goodneſs; it is whitiſh and tranſparent, whilſt the moſt ordinary is made at Paris, and is black and opake. The reaſon of this difference, according to Lewis, ariſes from the Flemiſh and French employing bones and ſinews, which do not afford ſo ſtrong a glue as ſkins, from which the Engliſh manufacture their glue. According to this chemiſt, the method of preparation is, to ſteep and waſh the parings or cutting of the hides in water; they are then boiled with freſh water till the liquor grows thick, when it is ſtrained through baſkets, ſuffered to ſettle, and afterwards further evaporated, till, on being poured into flat moulds, it unites, on cooling, into ſolid cakes, which are cut in pieces and dried upon a kind of net. Lewis.

Grenet has been occupied for ſeveral years with the melioration of this ſubſtance; he began by reading every thing already written on the ſubject; meditated very much on the qualities of the ſubſtances employed; and ſubmitted to experiment thoſe which had not been made uſe of, Grenet.

and which appeared to him to be proper for it's preparation. Bones, however, produced it abundantly, and with great facility; he firft deprived them of their fat, and procured the jelly by fimple ebullition; and this, when converted into glue by drying, he found to be much fuperior to the French kind, and nearly equal in goodnefs to thofe of the beft markets.

Parmentier. Parmentier, and Pelletier, who have alfo made experiments tending to the fame end, obtained from 6lbs. of rafpings of the button makers, 1lb. of glue, fimilar to the Englifh fort. From the rafpings of ivory the glue was more coloured, but equally as good. The rafpings of horn they found to afford no glue.

As jellies acquire more or lefs colour by expofure to heat, on being brought to a proper ftate of exficcation, to procure glue as little coloured as poffible, the lefs time it is expofed to heat the better; hence, by ufing only a fmall quantity of water to extract the jelly, a lefs evaporation is neceffary to concentrate it, fo as to form that fubftance on cooling, and confequently a lefs expofure to the fire; and if the jelly be afterwards cut into thin tablets or cakes, they will likewife be more eafily dried. To following this plan, the Flanders glue is faid to owe it's whitenefs and tranfparency; whereas by much expofure to heat, the parts become carbonized and black.

Glues differ from each other in their confiftence, colour, favour, odour, and folubility; fome of them diffolve very readily, when agitated in cold water, others are only foluble in boiling water; the beft ought to be tranfparent, of a yellow, inclining to a brown colour, without odour or favour; it fhould be perfectly foluble in water, forming a vifcous fluid with it of an uniform confiftence, and which on becoming dry, preferves equally, in every part, it's tenacity and tranfparency, and, in general, attains more folidity, colour, and vifcidity, according to the age

and ſtrength of the animal from which it has been extracted.

Clennel has given the moſt minute account of the making of glue, which was obtained during a viſit to a manufactory in Southwark. He informs us, it is made from the parings of hides, horns of different kinds, pelts from furriers, and the hoofs and ears of horſes, oxen, calves, ſheep, &c. quantities of which are imported in addition to the home ſupply, by many of the great manufacturers of this article. Theſe are firſt digeſted in lime-water to cleanſe them, as far as it can, from any greaſe and dirt; they are then ſteeped in clean water, ſtirring them well from time to time; they are afterwards laid in a heap, and the ſuperabundant water poured out; they are then boiled in a large braſs caldron with clean water, ſkimming off the dirt as it riſes, which is further cleanſed by putting in, after the whole is diſſolved, a little melted alum, or lime finely powdered, which, by their deterſive properties, ſtill further purge it; the ſkimming is continued for ſome time, when the maſs is ſtrained through baſkets and ſuffered to ſettle, that the remaining impurities, if any, may ſubſide; it is then poured gently into the kettle again, and further evaporated, by boiling a ſecond time, and ſkimming, until it becomes of a clear but darkiſh brown colour; when it is thought to be ſtrong enough (which is known either by the length of time a certain quantity of water and materials have boiled, or by it's appearance during ebullition), it is poured into frames and moulds about ſix feet long, one broad, and two deep, where it hardens gradually as the heat decreaſes; out of theſe troughs or receivers, it is cut when cold by a ſpade, into ſquare pieces or cakes, and each of theſe placed within a ſort of wooden box, open in three diviſions to the back; in this the glue, as yet ſoft, is taken to a table by women, where they divide it into three pieces, (when, by miſtake, Clennel.

they cut only two, that which is double the ſize is called a biſhop, and thrown into the kettle again) with an inſtrument, not unlike a bow, having a braſs wire for it's ſtring; with this they ſtand behind the box, and cut by it's openings from front to back; the pieces thus cut, are taken out into the open air, and dried on a kind of coarſe net work, faſtened in moveable ſheds of about four feet ſquare, which are placed in rows in the gluemaker's field, (every one of which contains four or five rows of net work); when perfectly dry and hard it is fit for ſale.

According to Clennel, that is thought the beſt glue which will ſwell conſiderably without melting, by three or four days immerſion in cold water, and recover it's former dimenſions and properties by drying. Glue that has got froſt, or that looks thick and black, may be melted over again and refined, with a ſufficient quantity added of freſh, to overcome any injury it may have ſuſtained; but it is generally put into the kettle after what is in it has been purged in the ſecond boiling. To know good from bad glue, the purchaſer ſhould hold it between his eye and the light, and if it appears of a ſtrong dark brown colour, and free from cloudy or black ſpots, the article is good.

Size. A ſuperior and even colourleſs glue, called *ſize*, is obtained from eel-ſkins, vellum, parchment, and ſome of the white kinds of leather, &c. but this is much too expenſive for common uſe, and is only employed by thoſe artificers whoſe work requires ſo delicate a ſubſtance, and where glue would be too groſs. Such as uſe ſize are the paper-maker, the linen manufacturer, the gilder of gold, poliſher, and the painter in various colours, &c. For the ſame purpoſe the ſkins of the cat, rabbit, and hare, are employed.

Hatchett on mucilage, ſize, and glue. Hatchett, in his experiments to inveſtigate the compoſition of membrane, obtained various quantities of ge-

latin, and when the folutions of it were gradually reduced by evaporation, he had opportunities of frequently obferving the various degrees of vifcidity and tenacity which characterize mucilage, fize, and glue. The difference in the vifcidity and tenacity of the varieties of thefe fubftances, is, according to this chemift, evidently an inherent quality, and not caufed by the degree of infpiffation; for if this was the cafe, mucilage, fize, and glue, when dry, he thinks, would be of equal quality, which is contrary to experience; for the varieties of glue are not of equal tenacity. Glue, made from certain parts of animals, fuch as the fkin, being more tenacious and of better quality than that which is made in fome places from feet and finews. It differs alfo according to age; for the beft and ftrongeft glue is always obtained from the more aged animals, in whom the fibre is found to be moft coarfe and ftrong. But a longer continued boiling appears requifite to extract it, and the more vifcid glues are obtained with greater difficulty than thofe of a lefs vifcid quality, which may more properly be called fize, and this difference is to be obferved, when mufcle is boiled with repeated and frequent changes of water. Gelatin thus obtained, whether in the ftate of mucilage, fize, or glue, when completely dried, is affected by water according to it's degree of vifcidity; for when cold water is poured on dry mucilage, it diffolves it in a fhort time; but if cold water is poured on thefe varieties of gelatin, which when diffolved in a proper quantity of boiling water, would, by cooling, form jellies more or lefs ftiff, it acts on them in different degrees, not fo much by forming a complete folution, as by caufing them to fwell and become foft; fo that when a cake of glue has been fteeped three or four days in cold water, if it fwell much without being diffolved, and, when taken out, recovers it's original figure and hardnefs by drying, fuch glue is confidered to be of the beft quality.

The animal mucilage, which Hatchett employed, was obtained from the coroll. officin. as he found it to be pure, and not partly modified into gelatin or animal jelly; or in other words, the mucilage had not acquired the degree of viscidity requisite to form a gelatinous substance. The expression is not therefore to be understood as alluding to any essential difference in composition, but only to denote some variation in the degree of consistency; for the whole may be comprehended under the term gelatin, (vide art. Gelatin) of which mucilage may be regarded as one extreme, and the strongest and most viscid glue as the other.

As the qualities of gelatin are so various, so the properties of the substances in which it is present as a component part, are much influenced by it; and when, for example, skins of different animals are compared, he always found, that the most flexible skins afforded gelatin more easily, and of a less viscid quality, than those which were less flexible, and of a more horny consistency. The skin of the eel possesses great flexibility, and it affords gelatin very readily and in large proportion. The skin of the shark also, which is commonly used by cabinet makers to polish their work, was also soon dissolved, and formed a jelly like the former. The thin and tender epidermis or cuticle of these skins, although not soluble, was reduced into small particles by violent ebullition, and the spiculæ were also separated. The skins of the hare, rabbit, calf, ox, and rhinoceros, gave the same results, but gelatin from the hide of the rhinoceros, appeared the strongest and most viscid. In every one of the experiments, the true skin, or cutis, was principally affected (as Chaptal and Seguin have observed) by long boiling, but that of the rhinoceros far exceeded the others in difficult solubility. The cutis of these skins, when first boiled, swelled and appeared horny; it was then gradually dis-

ſolved; but in the cutis of the rhinoceros a few filaments remained, which at length contracted and adhered to the cuticle. The cuticle of the different ſkins was ſoftened, but not diſſolved; and as the cutis ſeems to be entirely formed of gelatin, ſo the cuticle appears to contain it, although in a ſmall proportion. It is, however, neceſſary to it's flexibility; for when, after long boiling, the cuticle of the ſkins was dried, it became a brittle ſubſtance, which was eaſily reduced to powder.

Hair was much leſs affected than ſkin. The cartilages of the articulations are as completely ſoluble as the cutis, when long boiled with water; but this is not the caſe with the other cartilages; the other afforded little or none. It was the ſame with reſpect to quill ſhavings, and the horns of different animals, which were next ſubjected to experiment, and all afforded ſmall quantities of gelatin, and the more flexible horns the greateſt quantity, with the greateſt eaſe, and, when deprived of it, and ſuffered to dry ſpontaneouſly, in the air, they become more rigid, and were eaſily broken. The horns were thoſe of the ox, ram, goat, and chamois, which are perfectly diſtinct from the nature of ſtags or bucks horn; for this is as different from the former, in chemical compoſition as in conſtruction. Like bone, it affords much phoſphat of lime, (vide bone) and like it, a large quantity of gelatin; and it is obſerved by Hatchett, that phoſphat of lime is generally accompanied by gelatin, as in ſtags horn, bone, ivory, &c. On the contrary, when carbonat of lime is the hardening ſubſtance, as in ſhells, madrepores, and millepores, no gelatin can be diſcovered; for he has frequently digeſted the ſubſtances many days in boiling diſtilled water, after having reduced them to a coarſe powder, that they might preſent a large ſurface, but never could diſcover the ſlighteſt veſtige of gelatin. Hence the above horns are very different from the compoſition of

ſtags horn, and yield gradually, and with great difficulty, only a ſmall quantity of gelatin.

Human nails and ſhavings of a hoof, long digeſted for ſeveral days, afforded like quill, only a ſlight cloud by nitro-muriat of tin. Tortoiſeſhell in ſmall thin ſlips and ſhavings were affected in a ſimilar manner.

Sponges and gorgoniæ, bladder and other membranes, afforded more or leſs gelatin.

He found the effects of the dilute nitric acid on the ſubſtances he ſubjected to experiment for the obtaining of glue, exactly kept pace with thoſe of boiling water, of which he gives an inſtance of two pieces of ſkin recently taken from the ox, one of the pieces was boiled in water till the whole of the cutis was diſſolved; after which the cuticle remained, although very feeble in texture, while the hair did not ſeem to have ſuffered any material alteration. The other piece was ſteeped in nitric acid, diluted with about four meaſures of diſtilled water. At the end of five days the cutis was diſſolved, and the cuticle was become of a looſe and feeble texture, but the hair had not ſuffered any apparent change excepting that of being ſlightly tinged with yellow. In both caſes, therefore, the effects of boiling water, and of acid, were ſimilar; and he found them to be more powerful on thoſe parts which were the moſt gelatinous; and as water diſſolves mucilage more ſpeedily than ſize, and this laſt more ſpeedily than ſtrong viſcid glue, ſo are the effects of very dilute nitric acid on the ſame ſubſtances.

In reſpect to œconomical purpoſes, all animal ſubſtances whatever, (excluſive of carbonat and phoſphat of lime) may be converted into two ſubſtances of much utility, viz. glue and ſoap, with the additional advantage that thoſe parts which would be rejected in making the one, are the moſt proper to prepare the other. The offenſive ſmell of Chaptal's ſoap is conſidered as an objec-

tion, but this may be removed by expofing the foap for fome time in flat veffels to the air; after which, it may be reduced to the proper degree of confiftency by a fecond boiling.

ISINGLASS OR ICHTHYOCOLLA.

Ifinglafs, and the method of making it.

THIS is another fine fpecies of glue, extracted from certain fifh, very common in the Ruffian feas, and which are found on entering the large rivers. Hence the Wolga, Lyak, the Don, and Danube, afford large quantities, as well as the Cafpian fea; they are even to be found in Siberia, known by the name of kle or kla, from being filled with the gluey matter. It is prepared in Mofcovy from the air bladders of the *fturgeon* and the *fterled*, which afford the moft beautiful ifinglafs. After thefe, a fifh called *ferrijouga* gives the next in quality; and laftly, the *belouga*. There is likewife another part of the fifh fituated near the back, to which it is attached, called the *vefiga*, which makes excellent ifinglafs, and this is faid to be particularly the cafe with the fifh *accipenfer*. It is perhaps the *founds* of the Englifh.

In general the fifh of frefh water is preferred, affording an ifinglafs which is more delicate, more flexible, and exceedingly tranfparent; and there are numbers of fmall ones in the above rivers which excel in affording it in a fuperior degree.

The method of making the ifinglafs is, after the bladder has been extracted, it is wafhed with water to clean it of the blood, if any remains, but not otherwife. It is then cut lengthways, and the exterior membrane taken off, which is of a brown colour, whilft the other membrane, already mentioned, is fo fine and white as to be taken from the fifh with difficulty. They are firft formed into rolls of the thicknefs of the finger, placing the fine membrane in the middle, and

are then ſuſpended in the air to dry gradually. Iſinglaſs is, however, converted into various ſhapes, as fancy directs. The beſt is made in the ſummer, as it is apt to have a diſagreeable odour, if formed during the winter; at the ſame time, it diminiſhes in weight, and it's gelatinous qualities are affected. In order to be good, iſinglaſs ſhould be white, ſemitranſparent, without odour, and perfectly dry. To diſſolve it, it is reduced to ſmall pieces by breaking it with a hammer, and then cut with ſciſſars. In this ſtate it may be diſſolved in water, by a gentle heat, ſtirring it at times. It diſſolves beſt, however, in ſpirit of wine, in which it particularly differs from common glue. The Ruſſians have another kind of iſinglaſs, in the making of which, heat is uſed; it comes from Gouriefgorodon, a ſmall town on the Yaix, but it is of an amber yellow colour, and is not ſold in commerce.

Beſides the above mentioned parts of fiſh from which iſinglaſs is made, a ſort for the purpoſes of clarifying different wines and other liquors, is made from a variety of other fiſh, ſuch as ſea wolves, porpoiſes, ſea cows, ſharks, cuttle fiſh, whales, and all other fiſh without ſcales. Of theſe, the head, tail, bones, or cartilages, fins, ſkin, and indeed every part of the body, except the fleſh and fat, or oil, are boiled in a large quantity of water, ſo as to prevent any acceſs of ſmoke. It muſt be well ſhimmed in proportion as impurities ariſe. When all the viſcous part is extracted, it is taken from the fire and left to repoſe, and afterward filtered through a linen cloth. The clear filtered liquor is expoſed to heat a ſecond time, until it is become ſo thick, that if a drop be placed on a plate, it fixes on cooling. It is then taken off the fire and left till it has acquired a certain conſiſtence by cooling, when it is poured on tables of ſtone or marble, or other hard bodies, from which it may be eaſily ſeparated, and at a proper time before all the heat is diſſipated, it

is cut into tablets, and dried in the ſhade. This ſort of iſinglaſs, which, if properly made, is white and tranſparent, and on diſſolving affords no ſediment, is very ſerviceable in the clarifying of wine, fixing the matter in the compoſition of crayons, and for other purpoſes, ſuch as the ſtiffening of ſilk and gauzes, the joining pieces of glaſs, or porcelane, making artificial pearls, and forming Engliſh ſticking plaſter. Iſinglaſs is of all ſhades, from a perfect tranſparency to a black; but the worſt pieces are large and yellowiſh, of a diſagreeable odour, and opake. A beautiful black may be given it by carbonizing it in a ſmall degree.

According to Hatchett, 500 grains of iſinglaſs, perfectly exſiccated, yielded 56 grains of coal, from which 1 grain and half of earthy reſiduum were obtained by incineration, which laſt being deducted, the proportion of coal appears to have been 54,50 grains. The 1,50 grs. were phoſphat of ſoda, mixed with a very minute *proportion of phoſphat of lime.* It's component parts.

Newmann's Chemiſtry—Rapport fait au Bureau de Conſult. ſur le Colle forte des os propoſé, par M. Genet, par M. Parmentier, et Pelletier. an. dech. v. 13, p. 192. —Macquer's Wœrterbuch, art. *Leim.*—Encyclop. Méth. Arts et Métiers. t. 3, p. 60.—Nicholſon's Journal, No. 8; Oct. an account of the art of making glue.

HARD PARTS.

The principal ufe of thefe parts is to defend or fupport the animal, which, from their firm and fixed nature, they are capable of performing. They may be divided into bones, horn, fhells, and zoophytes.

BONES.

Bones. These are the hardeft and moft firm of all the parts of an animal, their texture is clofe and compact, more or lefs brittle, very little if in any degree flexible, and not capable of being foftened by heat, like horn, fo as to receive the impreffions of different figures. When clean and in a healthy ftate, they are white; when difeafed, yellowifh, brown, or blackifh, very porous, and often corroded.

Expofed to a boiling heat. Bones, when deprived of their marrow (vide *fat*) and expofed to a boiling heat in water, afford a quantity of gelatin, and this is eafier extracted if they be previoufly broken into fmall pieces or rafped (vide *glue*.)

Their diftillation. By diftillation in a retort, there arifes an alkaline phlegm, a fetid empyreumatic oil, and much concrete volatile alkali; a black coal remains behind, which is very compact and very difficult to incinerate.

Calcination. The afhes are white, and afford to cold water a fmall quantity of cretaceous foda; hot water afterward takes up a certain quantity of felenite; the refidua of thefe lixivia is infoluble in water, and is the phofphat of lime difcovered by Gahn of Stockholm, in 1769. Unlefs the fire be long continued and very ftrong, the large entire bones ftill remain black in the middle; and if calcined in a furnace, in the midft of charcoal, they remain lumi-

nous in the dark. By a very ſtrong heat, they are ſemi-vitrified, and reduced into a very hard and white kind of porcelane.

Acids when diluted make them flexible and tough like leather, by decompoſing the calcareous phoſphat they contain, by which means they are deprived of their earth. It was by means of the vitriolic acid, that Gahn, firſt mentioned, made the diſcovery, and by this he ſeparated the phoſphoric acid. Kunckel and Beccher, who procured it from teeth, knew of it's exiſtence in bones. Action of acids.

In 1777, phoſphorus was prepared from bones by the means of this acid, by the chemiſts of Dijon, viz. Morveau, Marets, and Durande. For this purpoſe, bones of the ox, calf, ſheep, &c. were placed in ſtrata upon charcoal, in a furnace, and calcined, by which it was found that 41lb. of dried bones afforded nearly 24lb. perfectly calcined to whitene ſs. Theſe were then pulverized in an iron mortar and ſifted ; 12lb. were taken and put into a ſtone-ware pan, common concentrated vitriolic acid was poured upon them until the effervefcence ceaſed, and there was even a ſmall exceſs ; the mixture was then agitated, a ſufficient quantity of water was added to favour the action of the acid, until it was become of the conſiſtence of a clear ſoup, and it was then expoſed for three hours to the heat of a ſand bath. This laſt, however, may be diſpenſed with, by letting it ſtand at reſt for ſeveral hours, until it proves thick. Vitriolic. Preparation of phoſphorus.

It is then diluted with a good deal of water, and filtered through cloth or paper, taking care to waſh the reſiduum with warm water until it paſſes through taſteleſs, and no longer precipitates limewater, which proves that it no longer contains diſengaged phoſphoric acid. The filtered liquor being evaporated, gradually depoſits a beautiful white ſilky ſubſtance, which is ſelenite, and muſt be ſeparated by filtration, taking care to waſh it with a ſuffi-

cient quantity of water to carry off any phosphoric acid that may adhere to it. The filtrations are repeated until the fluid deposits no more precipitate; it is then evaporated to the consistence of honey, when it appears with a brown and greasy aspect. If it be gradually heated in a crucible till it ceases to emit a sulphureous, and as it were an aromatic smell, and no longer boils, it acquires a semivitreous consistence, is of an acid savour, and attracts humidity from the air. Exposed to a great degree of heat, it is fused into a transparent, hard, insipid, insoluble matter, without any acidity. The above quantity of bones afforded about 2 lb. 9 oz. of this semivitreous mass, independent of what adhered to the crucible.

This vitreous mass well pulverized, and mixed with one third it's weight of powdered charcoal, is put into an earthen retort, to which a receiver half filled with water, and pierced with a small aperture is adapted; the fire is then increased by degrees till the retort is heated to whiteness, at which time the phosphorus passes over in drops. The whole operation is from five to seven or eight hours, according to the quantity of matter distilled, and the heat the furnace is capable of giving. From the above quantity, 6 oz. 7 drachms of beautiful phosphorus were obtained. Fourcroy says, that from 6 lb. of bones, 20 ozs. or a little more of the vitriform residue is obtained, which afford about 3 oz. of phosphorus, and a few drachms of phosphorus half decomposed, which is nearly the same as the above. It is not necessary for the making of phosphorus to carry the operation further than till the matter has acquired the consistence of sirup, which may be conveniently performed in a copper vessel, and instead of a receiver, the neck of the retort may be just plunged simply in water contained in an open basin. Care must be taken that the neck of the retort be not plunged so deep as that the water may rise into the body

of the veſſel when abſorption takes place, but that the fluid in the baſin, may, by it's fall, ſuffer air to enter; in this caſe a ſmall quantity of the phoſphorus in the neck of the retort, may be burnt, but the quantity loſt is very inconſiderable.

Experiments with the vitriolic acid were likewiſe made by Nicolas, Pelletier, Bonvoiſin, &c.

It has been ſeen that the oſſeous matter may be diſſolved by the vitriolic acid. Some chemiſts have likewiſe employed the nitrous to extract the phoſphoric acid. It was by this means that Scheele ſucceeded in preparing phoſphorus ſo early as the year 1771, and he has been oppoſed to Gahn, although erroneouſly, as the firſt diſcoverer. He diſſolved, by warm digeſtion, 4 lbs. of white calcined bones, coarſely pulverized, in 8 lbs. of nitrous acid, diluted with an equal quantity of water; to this he added four times the quantity more of water, which formed nitrat of lime; the ſalt remaining in ſolution, together with the diſengaged phoſphoric acid. On this mixture he poured diluted vitriolic acid, which ſeizing the lime from the nitrous acid, formed ſelenite. This ſalt being precipitated by it's inſolubility, was ſeparated by the filter after reſting 24 hours, lixiviated, and the lye filtered and added to the firſt liquor. This was then evaporated, the ſelenite which was depoſited ſeparated, and diſtilled to the conſiſtence of ſirup; then levigated with two pounds of charcoal powder, expoſed in a retort with a receiver adapted to it, half filled with water, to a ſtrong fire, increaſed until phoſphoreſcent vapours aroſe, and the phoſphorus afterward clarified. Nitrous.

This method, employed by Scheele, was followed by Crell and Rouelle, who only made uſe of the vitriolic acid to precipitate the calcareous earth. This is an expenſive method, but according to Morveau, has great advantages, for the nitrat of lime being more ſoluble than ſele-

nite, there is no reafon to fear that the falt which is produced fhould prevent the action of the menftruum; and fince the vitriolic acid is only to decompofe a liquid falt, there is certainty of not exceeding the quantity, which is a very important circumftance, this acid retaining felenite in folution; and all chemifts agree, that the more felenite remains in the liquor, the lefs phofphorus is obtained. According to the fame chemift, it is likewife very proper to *try the liquor* after it has been filtered, as Rouelle advifes, by pouring into it a few drops of vitriolic acid, and of the nitrous folution of the offeous earth, as the firft renders it turbid if there remains any of the nitrat of lime undecompofed, and the fecond difcovers an excefs of vitriolic acid.

Muriatic. This acid was employed by Wiegleb for the folution of bones, looking upon it to be more advantageous for the precipitation of the felenite; he, however, allows that there was ftill fome remaining, after the firft diftillation of the liquor; and it may be eafily fuppofed that the muriat of lime muft be more fixed than the nitrat of lime. Having feparated the felenite as much as poffible by the ordinary means, he added ammonia as a further precipitant, and diftilled in a glafs retort the precipitated liquor, which he calls ammoniacal phofphoric falt; by this means he obtained in the receiver fome cauftic volatile alkali, a portion of ammoniacal falt in the neck of the retort, and at the bottom fome phofphoric acid, which he fays had attacked the glafs; he then diffolved it in warm water, evaporated the folution to drynefs, melted it afterward in a crucible, poured out the matter which refembled a glafs only in appearance, and which was very acid, and deliquefced in the air; and by this procefs he expected a very pure *phofphoric acid*, fuppofing that this acid paffes to a glacial ftate only from the earths which remain in it.

The method followed by Wiegleb, it is evident, is incapable of increafing the product in the making of phofphorus; but according to the obfervation of Morveau, it may be of fome ufe in the preparation of *phofphat of ammonia*. To obtain which, however, in it's pure ftate, he has himfelf propofed the following. Calcined bones are to be diffolved in diluted vitriolic acid, taking care to ufe lefs acid than is neceffary to diffolve all the offeous earth. It is then to be evaporated to feparate the felenite; and if the operation be well managed, not only very little of this falt will remain in the liquor, but not an atom of vitriolic acid. This, however, may be tried, by adding a few drops of the nitrous folution of bones, which will caufe no turbidnefs, if no acid remains. Volatile alkali is then to be added, even in it's cauftic ftate, fo as to faturate the phofphoric acid, which will form immediately an almoft folid mafs that muft be diluted with water, in order to filter it, and the filtered liquor is a real folution of phofphat of ammonia, which, by fpontaneous evaporation, affords very beautiful cryftals of that falt, and which has been fo laborioufly fearched for in urine. It is, however, mixed with a fmall quantity of phofphat of foda, which feparates by effervefcence in the open air. The calcareous phofphat, remaining on the filter, may be decompofed by the vitriolic acid for the making of phofphorus, fo that nothing may be loft.

Method of obtaining phofphorus by Morveau.

The phofphoric acid has likewife been obtained from other bones befides thofe already mentioned. Berniard obtained it from foffile bones; likewife from the bones of the elephant, whale, porpoife, elk, ox, teeth of the feacow, the human fpecies, and grinders of the elephant. From his experiments it appears, that all thefe bones afforded the fame fubftances, and contained phofphoric acid in different proportions. The Marquis de Bouillon obtained a phofphoric glafs from ivory, the head of a

A variety of bones affords it.

ſturgeon, and Fontana from the bones of fiſhes. Calcined bones generally afford one third of their weight of this acid; and Nicholas obſerves, that the bones of young animals do not contain it in ſuch large quantity as thoſe of old ones; and the ſame may be ſaid reſpecting the quantity of earth to which it is united. Thus the bones of the fœtus are ſaid to contain about one third part of earth, in the adult nearly one half, whilſt in old age it compoſes the greater part. On the contrary, the younger the animal, the greater is the proportion of gelatin in the bone. According to Accum, fiſh bones contain nearly one ſixth more phoſphoric acid than the bones of quadrupeds.

Action of alkalis.

From the experiments of the academy of Dijon, carbonated alkalis decompoſe the phoſphat of lime in bones. A ſmall quantity of alkali is alſo uſed in bleaching them; for, when boiled in a large proportion of water, the alkali forms a ſoap with the fatty matter. But the beſt method of bleaching bones is given by Mr. Smith of Briſtol. Being ſtruck with the effects of the bleaching liquor on cotton and linen, he applied it to the whitening of bones. Having in his poſſeſſion a cranium lately prepared, perfectly clean and inodorous, but ſo brown as not to be worth preſerving, he expoſed it with the vertebræ of the neck to an oxygenated muriatic atmoſphere; for which purpoſe he adapted a cork, with a ſtop-cock driven through it, to the aperture made for the candle, at the bottom of a common lamp-glaſs. For a retort he uſed a Florence flaſk, which contained one fourth of an ounce of black calx of manganeſe, mixed with half an ounce of muriatic acid, and a long bent tube of glaſs fixed into it's neck ſerved to direct the product at pleaſure.

Smith's experiment on bleaching of bones by oxygenated muriatic acid.

The ſkull had been immerſed for twelve hours in a weak cauſtic ſolution of potaſh; but he has not aſcertained whether this is abſolutely neceſſary. The lamp, which

contained thefe bones thus prepared, was placed in a large trough of water. The ftop-cock at the end afforded the means of filling it with water by exhaufting the column of air above. It now remained to diflodge the water, by placing the flame of a fpirit lamp under the retort, and the extremity of the tube under the lamp glafs. In a few minutes, the yellow oxygenated muriatic acid was evolved, and, as the water funk, thofe bones expofed to it's influence, affumed the fame appearance. This operation was continued till the glafs was emptied; but it was found neceffary to continue the procefs flowly, in order to recruit the air that had been abforbed by the preparation and water, demonftrated by the rifing of this fluid. In fix or eight hours the glafs was removed, and the head, which was of a bright golden colour, was expofed to the open air and the rays of the fun. As it dried, it became paler, and covered with fmall fhining cryftals, which were wafhed off in rain water, and the bone was become fo beautifully white as to exceed in appearance any thing he had feen before of the fame kind. With old bones this procefs did not fucceed fo well as with recent; but even thefe, in fome cafes, were well bleached. The cranium being enclofed in a dark cafe, became rather diminifhed in it's whitenefs, from the exclufion of the light; but this gentleman informs us, it ftill retains it's beauty, fufficiently to demonftrate the fuperiority of the procefs.

Their component parts according to Prouft.

With refpect to the other component parts of bones, fome flight mention had been made of the prefence of a little felenite; and, according to Prouft, they are compofed of mineral alkali, felenite, phofphoric lime, and a peculiar fubftance; but the phofphat of lime was fuppofed to be the principal offifying matter in them.

Hatchett's experiments on bones.

A more perfect and fatisfactory analyfis has been made by Hatchett. He obferves, that it is fcarcely neceffary to mention the ufual effects of acids on bones when fteeped

in them: for it is well known, that in every operation of this nature, the offifying fubftance, which is principally phofphat of lime, is diffolved, and a cartilage or membrane of the figure of the original bone remains. With refpect to the menftrua, precipitants, and mode of operation, the bones and teeth were fubjected to the action of the acetous, or diluted nitric and muriatic acids. The diffolved portion was examined by carbonat of ammonia, or of potafh, which precipitated the carbonat of lime, and the phofphat of lime was precipitated by pure or cauftic ammonia. In experiments, where the quantity of the fubftance would permit, the phofphoric acid was alfo feparated by nitric or fulphuric acid. The phofphoric acid, thus obtained, was proved, after concentration, by experiments well known to effect fuch purpofes. As the principal object was to difcover the moft prominent character, this chemift did not attempt, in general, to afcertain, minutely, the proportions fo much as the number and quality of their refpective ingredients.

He found that the bones of fifh, as thofe of the falmon, mackerel, brill, and fkate, afforded phofphat of lime, and the only difference between them, and thofe of quadrupeds, &c. was, that the firft appeared, in general, to contain more of the cartilaginous fubftance, relative to the phofphat of lime, than is commonly found in the laft. The different bones alfo of the fame fifh were various in this refpect, and the bones about the head of the fkate only differed from cartilage, by containing a moderate proportion of phofphat of lime.

It is at prefent believed, that phofphat, with fome fulphat of lime, conftitutes the whole of the offifying fubftance; and he thinks it probable, that the formation of bone from cartilage depends on the phofphat of lime; but whether this be the cafe or not, it is neceffary to

mention a third fubftance that occurred in the courfe of his experiments.

When human bones or teeth, as well as thofe of quadrupeds and fifh, whether recent or calcined, were expofed to the action of acids, an effervefcence, although at times but feeble, was produced. This circumftance he did not at firft particularly notice, but the following experiments excited his attention.

After the phofphat of lime had been precipitated from the folutions of various teeth and bones, by pure ammonia, he obferved, that a fecond precipitate, much fmaller in quantity, was obtained by the addition of carbonat of ammonia. This fecond precipitate diffolved in acids with much effervefcence, during which, carbonic acid was difengaged, and felenite was formed by adding fulphuric acid. Moreover, the folution of this precipitate contained no phofphoric acid, nor did the liquor from which the precipitate had been feparated, afford any trace of it.

This precipitate was therefore carbonat of lime; but ftill he was not certain that it exifted as fuch, in the teeth and bones; and as fulphat of lime had been already proved by former chemifts to exift in bones, he was defirous of afcertaining, whether the carbonat of lime he had obtained had been produced from the fulphat having been decompofed by the alkaline precipitate, or whether the greater part had not exifted in the bones in the ftate of carbonat.

Each of the folutions in nitric acid afforded a precipitate with nitrat of barytes; but the quantity of fulphuric acid thus feparated appeared by far too fmall to be capable of faturating the whole of the carbonat of lime obtained from an equal quantity of the folution. To prove, therefore, the prefence of the carbonic acid, and

the confequent formation of the carbonat of lime, portions of the various teeth and bones were immerfed in muriatic acid at feparate times, and the gas produced was received in lime-water, by which it was fpeedily abforbed, and a proportionate quantity of carbonat of lime was obtained.

Teeth. This chemift then examined the enamel of teeth. When a tooth, coated with enamel, is immerfed in diluted nitric or muriatic acid, a feeble effervefcence takes place, and the enamel is completely diffolved; fo alfo is the bony part, but the cartilage of that part is left, retaining the fhape of the tooth: or, if a tooth, in which the enamel is intermixed with the bony fubftance, be plunged into the acid, the enamel and the bony part are diffolved in the fame manner as before, *i. e.* the enamel is completely taken up by the acid, while the tooth, like other bones, remains in a pulpy or cartilaginous ftate, having been deprived of the offifying fubftance. Confequently, thofe parts, which were coated or penetrated by lines of enamel, are diminifhed in proportion to the thicknefs of the enamel which has been thus diffolved, but little or no diminution is obferved in the tooth. This has been noticed by Hunter, who, fpeaking of enamel, fays, " when foaked in a gentle acid, there appears no grifly or flefhy part with which the earthy part had been incorporated." Hatchet has alfo obferved, that when rafpings of enamel are put into diluted nitric or muriatic acids, they are diffolved without any apparent refiduum; but when rafpings of tooth or bone are thus treated, portions of membrane or cartilage remain, correfponding to the fize of the rafpings. According to Fourcroy and Vauquelin, 100 parts of enamel of teeth contain 43,3 of lime, 29,67 of phofphoric acid, and 27.10 of gelatin and water.

Hatchet has alfo examined the foffil bones of Gibraltar,

as well as some glossopetræ, or shark's teeth. The latter afforded phosphat and carbonat of lime; but the last was visibly owing principally to the matter of the calcareous strata, which had enclosed these teeth, and which had insinuated itself into the cavities left by the decomposition of the original cartilaginous substance.

Fossil bones and shark's teeth.

The bones of Gibraltar rock he found also to consist principally of phosphat of lime, and the cavities have been partly filled by the carbonat of lime, which cements them together.

Fossil bones resemble bones which, by combustion, have been deprived of their cartilaginous part; for they retain the figure of the original bone, without being bone in reality, one of the most essential parts having been taken away. Now such fossil or burnt bones can no more be regarded as bone, than charcoal can be considered as the vegetable of which it retains the figure and fibrous texture.

Bones, which keep their figure after combustion, resemble charcoal made from vegetables replete with fibre; and cartilaginous bones, which lose their shape from the same cause, may be compared to succulent plants, which are reduced in bulk and shape in a similar manner.

From these last experiments, this chemist doubts if bodies consisting of phosphat of lime, like bones, have concurred materially to form strata of lime-stone or chalk. As it appears improbable that phosphat is converted into carbonat of lime after these bodies have become extraneous fossils, he is of opinion that the destruction or decomposition of the curtilaginous parts of teeth and bones, in a fossil state, must have been the work of a very long period of time, unless accelerated by the action of some mineral principle: for, on putting the os humani of a man brought from Hythe in Kent, said to have been taken from a Saxon tomb, in muriatic acid, he found the

remaining cartilage nearly as complete as that of a recent bone. The difficult deftructibility of fubftances of nearly a fimilar nature, appears alfo from the mining implements formed of horn, not unfrequently found in excavations of high antiquity.

Component parts of bones.

From thefe experiments it appears, that bones are not earthy matters, as they were formerly fuppofed, and that they are neither compofed of calcareous earth and clay, as fome chemifts affirmed, nor of magnefia, as others were willing to imagine; but that they contain a certain quantity of gelatin, difperfed in fmall cavities, formed by the interval between the fibrous part which compofes their texture; and, although they may appear to refemble earthy fubftances, from their infolubility and firmnefs, they are proved to be formed of two earthy neutral falts, a large quantity of phofphat of lime, a fmall proportion of fulphat of lime, and fome carbonat of lime.

Offification.

In the firft origin of bones, the firft part that is formed is a membrane or cartilage of the requifite figure which, when the fubfequent fecretion of the offifying fubftance takes place, is penetrated by it, and more or lefs converted into the ftate of bone, the nature of which is more or lefs influenced by the greater or lefs predominance of the membranous or cartilaginous part, than by any other caufe; for it is by means of it that the bone acquires it's greater or lefs folidity; and, although the principal effects during offification are produced by phofphat of lime, it appears, that the fulphat or carbonat of that earth is neceffary; and, according to Hatchett, it is curious to obferve, that as the carbonat of lime exceeds in quantity the phofphat in cruftaceous marine animals, and in the eggfhells of birds, fo in bones it is vice verfa; and he thinks, that when many accurate comparative analyfes of bones have been made, fome may be found compofed only of phofphat of lime; and that thus, fhells,

containing only carbonat of lime, and bones containing only phofphat, will form the two extremities of the chain. Thus the hard fubftances are by no means paffive in the animal œconomy, being renewed and fubject to difeafe, as well as the other parts, and they are confidered by Fourcroy as real fecretory organs, the office of which is to feparate from the blood the peculiar faline fubftances, and more particularly the phofphat of lime, of which they are the refervoir, or place of depofition.

Hatchett, in a fecond paper read before the Royal Society, in London, has examined the fubftance of bones that remains after repeated boiling, or having been fteeped in dilute acids. For when a bone or piece of ivory has, by long boiling in water, been deprived of a great part of it's gelatin, and is afterward fteeped in a dilute acid, the offifying fubftance, as already obferved, is diffolved, and the cartilage remains, retaining the figure of the original bone; or if a fimilar bone or piece of ivory which has not been boiled, is fteeped in a dilute acid, (efpecially nitric acid) the offifying fubftance is diffolved; and at the fame time, but more flowly, the gelatin is feparated, and caufes the liquor to become yellow, when the phofphat of lime is precipitated by ammonia. The cartilaginous fubftance that remains after the gelatin has been thus feparated, is not eafily foluble in dilute acids, for (according to it's texture) many weeks and even months may elapfe before a fmall part is taken up; but in concentrated nitric acid, or in boiling dilute acid, it is readily diffolved. This fubftance, when dry, is femitranfparent like horn, and more or lefs brittle, and when fubjected to experiment, afforded the following refults. Further experiments of Hatchett.

1. When diftilled, a fmall portion of water, fome carbonat of ammonia, a fetid empyreumatic oil, carbonated hydrogen gas, and pruffic acid were obtained.

2. A fpungy coal, of a gray metallic luftre, remained;

this, by incineration, afforded a very fmall refiduum, which refiduum (on examining the fame fubftance in different bodies) was not always fimilar in quantity, even in portions of the fame fubftance; for 500 grains of tortoifefhell, taken from different famples, afforded from one fourth of a grain to three grains of refiduum, which confifted of phofphats of lime and foda; fometimes alfo a little carbonat of lime was prefent, but he does not confider thefe to be effential ingredients.

3. When boiled many days in diftilled water, the fubftance was foftened, and the water became flightly turbid with nitro-muriat of tin; but no effect was produced by the tanning principle.

4. Muriatic and fulphuric acids had little effect unlefs heated, and the fame was the cafe with nitric acid, much diluted, (the nitric acid he employed was 1,38, and this was diluted with two, three, or four meafures of diftilled water) or in a ftate proper to extract and feparate gelatin; but if the immerfion in the dilute acid was continued during fome weeks, the acid gradually acquired a yellow tinge, and when faturated with ammonia became of a deeper colour, without having it's tranfparency diluted.

5. The fubftance which had thus been long fteeped in the acid was much foftened, was become more tranfparent, and from being horny, was now more like a cartilaginous fubftance: when taken out of the acid, if it was immediately fteeped in pure ammonia, it changed to a deep orange colour, inclining to blood red; it was gradually and filently diffolved without any refiduum, and a deep orange or yellowifh brown coloured liquor was formed.

6. Or when taken out of the acid, if it was firft well wafhed in diftilled water and then boiled, it was alfo diffolved, and formed a pale yellowifh folution; this, by evaporation and cooling, became a jelly, which was

again foluble in boiling water, and was precipitated like gelatin by the tanning principle, and more flowly by nitro-muriat of tin.

7. If the nitric acid in which the fubftance was immerfed was not fufficiently diluted, or if heat was applied, the whole was rapidly diffolved, with a confiderable effervefcence and difcharge of nitrous gas.

8. This folution was yellow like the former, the colour being intenfe, in proportion to the quantity diffolved; and it was alfo changed to a deep orange or yellowifh brown by the addition of ammonia, without depofiting any precipitate, unlefs a large quantity had been diffolved.

9. The nitric folutions of this fubftance, when evaporated, afforded much the fame appearances as thofe of gelatin, but the coal which remained was lefs fpungy.

10. This fubftance was ftrongly diftinguifhed from gelatin by the effects produced, when boiled with cauftic fixed alkali, which formed with it an animal foap.

11. During the procefs, a confiderable quantity of ammonia was difcharged, and if the alkali was in excefs, fome coal was depofited.

12. When the animal foap was diffolved, diluted with diftilled water, and filtrated, if an acid (fuch as the acetous or muriatic) was added, a copious precipitate was obtained, which was rediffolved by an excefs of acid.

13. This precipitate being collected upon a filter, appeared at firft like a yellow or brownifh vifcid fubftance, which, when dry, was like a thick coat of varnifh, or dried white of egg, and in like manner was brittle, and broke with a gloffy fracture.

14. It burned like quill or tortoifefhell, leaving a fpongy coal, and when diftilled afforded fimilar products.

15. It was not readily foluble in dilute acids, and was acted upon by nitric acid and ammonia, like the fub-

ſtance from which it was obtained ; the properties alſo of it's ſolutions in nitric acid and ammonia were ſimilar.

16. With cauſtic lixivium of potaſh, it readily combined, and again formed animal ſoap.

17. It was not quite ſo inſoluble in boiling water as quill or tortoiſeſhell, and the water in which it had been boiled was not only made turbid by nitro-muriat of tin, but yielded a precipitate by oak bark after the manner of gelatin.

Theſe experiments proved, that this precipitate was the ſame as the original ſubſtance from which it had been obtained, and that the only change it had ſuffered was that of being rendered rather more ſoluble in boiling water.

From theſe experiments it alſo appears, that this cartilaginous body was quite diſtinct from gelatin in chemical properties, and having compared them with ſome experiments on inſpiſſated albumen, (white of egg) he found they correſponded in great meaſure.

He found this to be the predominant and eſſential part in the tiſſue or web of membrane, cartilage, ſponge, the horny ſtems of gorgoniæ, horn, hair, feather, quill, hoof, nail, horny ſcale, cruſt and tortoiſeſhell, varying in the colour of the ſoaps it formed.

Experiments of Merat-Guillot.

According to the experiments of Merat-Guillot, on the comparative proportions of the component parts of different bones, of which he employed 100 parts, exſiccating the products as much as poſſible, it appears that

	Gelatin.	Phoſphat of lime.	Carbonat of lime.	Loſs.
Human bones taken from the church-yard gave	16	67	1.5	15.5
Common dry human bones that had not been in the earth	23	63	2	2

Bones of the ox	3	93	2	2
Calf	25	51	traces	21
Horſe	9	67.5	1.25	22.25
Teeth of the horſe	12	85.5	0.25	2.25
Elephant or ivory	24	64	0.1	11.15
Bones of the ſheep	16	70	0.5	13.5
Elk	1.5	90	1	7.5
Stags horn	27	57.5	1	14.5
Bones of the pig	17	52	1	30
Hare	9	85	1	5
Hen	6	72	1.5	20.5
Egg ſhells	3	2	72	23
Bones of the pike	12	64	1	23
Carp	6	45	0.5	48.5
Viper	21.5	60.5	0.5	17.5
Lobſter ſhell	18	14	40	28
Mother of pearl	2.5	0	66	31.5
Crabs eyes	2	12	60	26
Red coral	0.5	0	53.5	46.
Jointed coraline	7.5	0	49	43.5
Bone of the cuttle fiſh	*8	0	68	24
White coral	1.5	0	50	48.5

With reſpect to the gelatin of the cuttle fiſh bones, this chemiſt thinks the product is not entirely compoſed of it, but that there is a portion which reſembles in it's nature that which forms the *charpente* of the polypi, known under the name of the lithophytes.

Deſirous of knowing whence aroſe the loſs, he expoſed 100 parts of crabs eyes to a ſtrong heat, and they loſt 22 parts; hence he thinks this loſs may be attributed to the water in the gelatin; but the four remaining parts to a portion of gelatin found diſſolved in the liquid uſed in the analyſis, and to a ſmall quantity of ſaline ſubſtance, which he did not examine. To make this analyſis more complete, he intends to add to it that of

the bones of carnivorous animals, fkeletons of infects, &c.

Difeafes of bones.

In fome difeafes of the bones, particularly in rickets, it is well known that there is a want of the phofphat of lime, on which account the bones become foft, and cannot fuftain the mufcular action; this happens more particularly in infancy, and as the ferum of milk is found by Fourcroy and Vauquelin to contain this earthy falt, a too fmall quantity of milk, or one that does not contain this falt in fufficient proportion, may produce or affift in producing this difeafe. Experiments have, therefore, been made where this falt is deficient, to apply it to the bones as a medicine, by means of the digeftive canals, which has been found to fucceed. Bonhomme informs us, that on giving the phofphat of lime to chickens, he found the bones acquired a greater degree of folidity and hardnefs, and their epiphyfes were much lefs fenfible than in thofe that were only fed in the ufual way; and having given it as a medicine to patients attacked by rickets, it produced the moft beneficial effects. The dofe to an infant was half a drachm of the phofphats of foda and lime mixed together, to be taken twice a day. It may be ufeful in fracture where there is difficulty in the formation of callus, in dentition, &c. This chemift likewife informs us, on the fubject of the phofphat of lime in milk, deftined for nourifhing the infant, that the nearer the milk is to the epoch of delivery, the more is the ferofity found charged with this falt; on the contrary, the farther it is diftant from birth, the more it lofes of this fubftance, in proportion, whilft the other nutritive parts of which milk is compofed increafe in an inverfe progreffion. This is eafily accounted for, if it be confidered that at the time of delivery a foftening has been made in all the joints of the mother, confequently a relaxation in the cartilages which unite them, and that

Phofphat of lime in milk, and it's ufe in offification.

the fractures of bones which occur at this time are flower in uniting than at other times. It is by fuch means that the humours which contribute the moft to the formation of the fœtus, it's increafe, and nutrition, carry in themfelves the effential bafis of folidity, and the elements of offification; in fhort, it is only when the offification is well pronounced, and the digeftive organs of the child are fufficiently ftrong to effect this part of animalization, that this bafis difappears in the maternal milk. On confidering thefe facts, we fhall be obliged to acknowledge the peculiar direction of nature, by which the phofphat of lime, in particular, becomes the matter of a neceffary fecretion, contrived for the ftrengthening of the organs, and the confolidation of the firft elements of the animal. It has been found, that the living bone may be coloured, by taking into the fyftem a colouring fubftance. This is verified with refpect to madder, which colours the bones red. The oldeft author that mentions this, according to Beckmann, is Lemnius, in a treatife, *de Miraculis Occultis Naturæ, in* 1564. He was a phyfician in Zealand, where madder has been cultivated from the earlieft ages, and where he had an opportunity of remarking it. He fays, the bones of animals become red by eating it's leaves. Mizaldus, who publifhed a book at Paris, in 1566, has taken what he fays of it from Lemnius.

Colouring of bones.

In 1736, John Belchier, an Englifh furgeon, (Phil. Trans. vol. 39, p. 287.) may be faid to have difcovered that madder, on being taken into the fyftem along with food, colours the bones of a red colour. What led to the difcovery, was the following. Having dined with a cotton printer, he obferved that the bones of the pork, which were brought to the table, were red. On expreffing his furprife at this circumftance, his hoft affured him that the rednefs was occafioned by the fwine feeding on the water mixed with bran, in which the cotton cloth

had been boiled, and which was coloured by the madder ufed in printing it. Belchier, to whom this effect was new, convinced himfelf by experiment, that what had been told him was true; that the red colour of the bones arofe from the madder, and he communicated his difcovery to the Royal Society. This fingularity was foon made known, and other experiments were tried. It was found, that befides the roots of madder, thofe of the galium, (yellow ladies bed ftraw) and other plants, which have an affinity to madder, produce the fame effects.

It appears, that the colouring takes place fooneft in young animals, and is ftrongeft where the bones are hardeft and thickeft. On the other hand, it does not reach the foft parts, and in general is not perceptible in the animal juices, except a little in the milk. Saffron or woad, with many other plants ufed in dying, have no effect in colouring thefe hard parts.

HORN.

Horn. THE horny parts of animals are produced from the forehead, and the extremities; hence they comprife not only the horns, commonly fo called, but the hoofs, nails, talons, and claws; which laft might, perhaps, afford the beft generic characters of horn. Thefe are more or lefs dry and hard, in fome degree flexible, very confiderably fo when heated, and fo cohefive as not to be capable of being pulverized in a mortar; they may likewife be made to receive impreffions of different figures, which properties, altogether, are fufficient to diftinguifh them from bone. Some, however, approach nearer to the laft; fuch are the horns of the ftag kind, and feem to form intermediate fubftances in point of hardnefs between bone and horn.

Neumann, who diftilled a great variety of thefe fub- Neumann.
ftances, found they afforded more or lefs of the fame products as other animal matters; he fubjected to this procefs the horns of the rhinoceros, ox, whalebone, hoof of the elk, &c. from which he obtained an urinous fpirit, an empyreumatic oil, volatile falt, and the refidue on calcination afforded a fixed faline matter.

Geoffroy obtained, on boiling one pound of hartfhorn Geoffroy.
in water, four ounces, two drachms, and fixty-three grains of dry gelatin; and on diftilling one ounce of this, he got two drachms of volatile alkali in a cryftallized ftate; and three drachms, thirty grains of yellow volatile alkaline fpirit, with a little dark-coloured empyreumatic oil; there remained two drachms and a half behind.

Dehne obtained from eleven pounds of hartfhorn, three Dehne.
pounds of fpirit and fome oil, and the refidue weighed fix pounds; and Model and Gunther found in the volatile fpirit an ammoniacal falt in cubic or rhomboidal cryftals, the acid of which, Leonhardi fuppofes, was the oxalic or the benzoic.

Macquer informs us, that horn is of the fame nature Macquer.
as the gelatinous part of animals, except that it contains lefs water and a larger proportion of earth; but that, like bone, it may in Papin's digefter be totally converted into a gelatinous mafs; that it affords by diftillation the common products of animal fubftances, with a pretty large quantity of coal very difficult to incinerate; it's afhes contain fcarcely any fixed alkali. The animal oil, efpecially the firft that comes over, on being again diftilled, is the oleum animale Dippelii. Of this the largeft proportion is to be got from the horns of the hart and chamois. According to this chemift, thefe two fpecies contain a larger proportion of the earth of bones, which diftinguifhes them from the horny fubftances, and forms a medium between them and bones.

Scheele and Rouelle.

Scheele and Rouelle obtained the phofphoric acid from calcined hartfhorn, and they looked upon it as containing more of this acid than even bones; and Nicholas prefers this fubftance to the coal, in the preparation of this acid. Although the coal of hartfhorn is difficult to incinerate, it undergoes that procefs much eafier than other horns, and nearly equal to bones, and when the coal is expofed to a ftrong continued heat, it is converted into very white afhes, ufed in medicine by the name of *cornu cervi uftum.*

Hatchett.

According to Hatchett, if horns are examined, he thinks very few will be found to contain phofphat of lime in fuch proportion as to be confidered an effential ingredient. He does not mean ftag or buck horns, for thefe have every chemical character of bone with fome excefs of cartilage; but he alludes to thofe in which the fubftance of the horn is diftinctly feparate from the bone, and which, like a fheath, covers a bony protuberance, which iffues from the os frontis of certain animals. Horns of this nature, fuch as thofe of the ox, the ram, the goat, and the chamois, afford after diftillation and incineration, fo very fmall a refiduum, of which only a fmall part is phofphat of lime, that he thinks this latter can fcarcely be regarded as a neceffary ingredient.

From fome experiments made on 500 grains of the horn of the ox, he obtained after a long continued heat only 1,50 grains of refiduum; and of this, lefs than half proved to be phofphat of lime. Seventy-eight grains of the horn of the chamois afforded only 0,50 of refiduum, of which lefs than half was phofphat of lime; and he thinks that fo very fmall a quantity cannot influence the nature of the fubftances that afforded it. The fame may be faid of cartilage, which does not contain the offifying fubftance, or phofphat of lime, as a conftituent principle, but it is mixed as an extraneous matter; and when ab-

fent, both cartilage and horn are moft perfect and complete. He thinks the frequent prefence of phofphat of lime in cartilaginous fubftances is not a proof of it's being one of their conftituent principles; but only that it has become depofited and mixed with them, in proportion to the tendency they may have to form modifications of bone, or according to their vifcidity with fuch membranes or cartilages, as are liable to fuch a change.

Hatchett has made fome experiments upon the fcales of different animals: Lewenhoeck had examined the *fcales of fifh* by means of a microfcope; and, as they appear to be formed of different membranaceous laminæ, and exhibit the colour and luftre of mother of pearl, it might, as Hatchett obferves, be expected, that they fhould prove to be of a fimilar nature with the fubftance of ftratified fhells, or, in other terms, that they fhould confift of membrane and carbonat of lime: but, when fcales, perfectly clean, and feparated from the fkin of different fifh, fuch as the falmon and carp, had been immerfed during four or five hours in diluted nitric acid, till they became tranfparent and perfectly membranaceous, the acid liquor being then faturated with pure ammonia, afforded a copious precipitate, which was proved to be phofphat of lime. The *fpiculæ* of the fhark's fkin were found to be of a fimilar compofition, from which he infers, that the fpiculæ and fcales of fifh may be confidered as true bony fubftances, in which the membranaceous parts are more predominant than in common bone. Scales.

He found, that phofphat of lime was afforded by the fubftances only; for when the different fkins, from which the fcales and fpiculæ had been taken, were feparately examined, no phofphat of lime was obtained. The filver or pearly hue of fifh fcales is only affifted and modified by the relative degrees of opacity, produced by the interpofition of the phofphat of lime, as the hue in pearl

and mother-of-pearl is by carbonat of lime: for this peculiar luſtre principally reſides in the membranaceous part, and remains with it, when the acetous or muriatic acid is employed as a menſtruum, but is completely deſtroyed by the nitrous acid. The *horny ſcales* of ſerpents, lizards, and ſuch like animals, differ from the foregoing, as they conſiſt merely of the membranaceous or horny ſubſtance, in a more or leſs indurated ſtate, and appear to be devoid of phoſphat of lime, as an oſſifying matter. Horny ſcales in general, and the ſcales of the manis pentedactyla may be mentioned as an example. They afford but very ſlight traces of gelatin after being boiled in diſtilled water, and this ſmall portion of gelatin can only be diſcovered by the tanning principle and by nitro-muriat of tin, unleſs a very large quantity of the ſcales has been employed. The hornlike cruſt, which covers certain inſects and other animals, were examined with reſpect to the gelatin they contained, particularly the plates which covered the body of a large African ſcorpion, which were not apparently affected, although digeſted for a long time in boiling diſtilled water. The tanning principle produced no alteration, when added to the water; but a faint white cloud appeared, upon the addition of nitro-muriat of tin.

SHELLS.

THESE appear to be of a much lefs compact texture than the bony and horny parts, and want not only the hardnefs of one but the flexibility of the other; they are much more brittle, and are eafily reduced to a powder. They may be divided into the fhells of eggs and the fhells of animals. Shells.

EGG SHELLS.

ALTHOUGH all eggs, which are produced by birds, are provided with a fhell, it has been obferved, that very fat hens will fometimes lay them deprived of this hard covering; but the reafon of this exception is unknown. The fhell is compofed of gelatin, phofphat, and carbonat of lime; it has, however, been fuppofed, that the phofphoric acid arifes from the gelatinous matter, and is not united with the earth, as in bones; the truth of which future experience is to determine. Wafferberg obferved that, on ufing the vitriolic acid as a menftruum, there arofe a fmell of fulphur. Vide Fæces. of eggs.

SHELLS OF ANIMALS.

Thefe, like the fhells of different eggs, are of various colours, but far exceed them in beauty as well as in utility. Till lately, however, very little was known with refpect to their component parts. of animals.

Neumann. According to Neumann, they yield lefs oily and faline matter by diftillation than either horn or bone; he has alfo obferved, that fome are more eafily converted into quicklime by fire than others, whilft a few fuffer no such change.

Hatchet's experiments. For the beft analyfis of fhells we are indebted to Hatchett, whofe experiments were made on thofe of marine animals; and the menftrua, precipitants, and mode of operation he made ufe of, were the following.

Their divifion into two kinds. The fhells he examined he divides into two kinds, from the fubftance of which they are compofed. The firft have a porcellaneous afpect, with an enamelled furface, and, when broken, are often in a flight degree of a fibrous texture. Thefe porcellaneous fhells are the various fpecies of voluta, cypræa, and others of a fimilar nature. The fecond kind have, generally, if not always, a ftrong epidermis, under which is the fhell, principally or entirely compofed of the fubftance called *nacre*, or mother-of-pearl, fuch as the oyfter, the river mufcle, the *haliotis iris*, and the *turbo olearius*.

Thefe were immerfed in acetous acid, or nitric acid diluted, according to circumftances, with 4, 5, 6, or more parts of diftilled water; and the folution was always made without heat.

The carbonat of lime was precipitated by carbonat of ammonia, or of potafh; and phofphat of lime (if prefent) was previoufly precipitated by pure or cauftic ammonia.

If any other phofphat, like that of foda, was fufpected, it was difcovered by folution of acetite of lead.

Tortoife-fhell. 500 grains of tortoife-fhell yielded 80 grains of coal; from which 3 grains of earthy matter being deducted, 77 grains remain for the proportion of coal. Thefe three grains confifted of phofphat of foda and lime, with fome traces of iron; but Hatchett thinks it probable that the

latter was accidentally prefent. Tortoife-fhell appears to be formed (as far as organic arrangement is concerned) in the way of ftratum fuper ftratum, and this ftructure is particularly to be difcovered after long maceration in diluted nitric acid; for then this fhell appears to be compofed like the black polifhed gorgonia, of membranaceous laminæ, and the varieties of horn differ only by a tendency to the fibrous organization.

PORCELLANEOUS SHELLS.

Shells of this defcription, when expofed to a red heat in a crucible for about a quarter of an hour, crackled and loft the colours of their enamelled furface; they did not emit any apparent fmoke, nor any fmell, like that of burned horn or cartilage. Their figure remained unchanged, excepting a few flaws, and they became of an opake white, tinged partially with pale gray, but retained part of their original glofs. Porcellaneous fhells.

Frefh fhells (whether entire or in powder) diffolved with great effervefcence in the various acids, and the folution afterwards remained colourlefs and tranfparent; but the burned fhells, on being diffolved, depofited a very fmall quantity of animal coal; and thereby the prefence of fome gluten was denoted, although the proportion was too fmall to be difcovered in the folution of the frefh unburned fhells.

The various folutions were filtered and examined by pure ammonia and acetite of lead; but there was no trace of phofphat of lime, nor of any other combination of phofphoric acid.

The carbonat of lime was afterwards precipitated by carbonat of ammonia; and from many experiments it

appeard, that porcellaneous ſhells conſiſt of carbonat of lime, cemented by a very ſmall portion of animal gluten.

Patellæ.

Previous to the experiments on the ſecond ſort of ſhells, this chemiſt examined ſome patellæ from Madeira. Expoſed to a red heat in a crucible, there was a perceptible ſmell, like that of horn, hair, or feathers. The proportion of carbonic matter, depoſited by the ſubſequent ſolution, was more conſiderable than that of the porcellaneous ſhells, and the proportion of carbonat of lime, relative to their weight, was leſs.

When the recent ſhells were immerſed in very dilute nitric acid, the epidermis was ſeparated, the whole of the carbonat of lime was diſſolved, and a gelatinous ſubſtance, nearly liquid, remained; but without retaining the figure of the ſhell, and without any fibrous appearance.

Theſe ſhells, therefore, contain a larger proportion of a more viſcid gelatinous ſubſtance than the porcellaneous, but the ſolution ſeparated from this gelatinous ſubſtance afforded nothing but carbonat of lime.

Pearly ſhells. Oyſter ſhell.

Pearly ſhells. In the examination of the ſhells compoſed of nacre or mother-of-pearl, he found that, on expoſing the ſhell of the common oyſter to a red heat, the effects were the ſame as thoſe obſerved in the patellæ, and the ſolution of the unburned ſhell was ſimilar, only the gelatinous part was rather of a greater conſiſtency.

Muſcles.

A ſpecies of river muſcle was next ſubjected to experiment. This, when burned in a crucible, emitted much ſmoke, with a ſtrong ſmell of burned cartilage or horn; the ſhell throughout became of a dark gray and exfoliated. By ſolution in the acids, a large quantity of carbonic matter was ſeparated, and much leſs carbonat of lime was obtained from a given weight of the ſhell, than from thoſe already mentioned.

On immerfing an unburned fhell in dilute nitric acid, a rapid folution and effervefcence at firft took place, but gradually became lefs; fo that the difengagement of the carbonic acid gas was to be perceived only at intervals. At the end of two days, nearly the whole of the carbonat of lime was diffolved, but a feries of membranes retaining the figure of the fhell remained; of which the epidermis conftituted the firft. In the beginning, the carbonat of lime was readily diffolved, becaufe the acid menftruum had an eafy accefs; but after this, it had more difficulty to infinuate itfelf between the different membranes, and of courfe the folution of the carbonat of lime was flower. During the folution, the carbonic acid gas was entangled, and retained in many places between the membranes, fo as to give the whole a cellular appearance.

The haliotis iris, and the turbo olearius, refembled this mufcle, excepting that their membranaceous parts were more compact and denfe. Thefe fhells, when deprived of their hardening fubftance, or carbonat of lime, by an acid menftruum, appear to be formed of various membranes, applied ftratum upon ftratum. Each membrane has a correfponding coat, or cruft of carbonat of lime; which is fo fituated, that it is always between every two membranes, beginning with the epidermis, and ending with the laft formed internal membrane. Haliotis iris, and turbo olearius.

The animals which inhabit thefe ftratified fhells increafe their habitation by the addition of a ftratum of carbonat of lime, fecured by a new membrane; and as every additional ftratum exceeds in extent that which was previoufly formed, the fhell becomes ftronger in proportion as it is enlarged; and the growth and age of the animal becomes denoted, by the number of the ftrata which concur to form the fhell.

Although the haliotis iris, and the turbo olearius, are

composed of the true mother of pearl, this chemist was induced to repeat the foregoing experiments, on some detached pieces of mother of pearl, such as are brought from China, and the results were precisely the same.

Mother of pearl. He, however, observes, that the membranaceous, or cartilaginous parts of these shells, as well as of the pieces of mother of pearl, retained the exact figure of the shell or piece, which had been immersed in the acid menstruum; and these membranaceous parts distinctly appeared to be composed of fibres, placed in a parallel direction, corresponding to the configuration of the shell.

Pearls. The same experiments were made on pearls, which proved to be similar in composition to the mother of pearl; and so far as the size would enable him to discern, they appeared to be formed by concentric coats of membrane, and carbonat of lime; by this structure, they much resemble the globular calcareous concretions, formed at Carlsbad, and other places, called pisolithes.

The wavy appearance, and irridescency of mother of pearl, and of pearl, are evidently the effects of their lamellated structure, and semitransparency, in which, in some degree, they are resembled by the lamellated stone, called adularia.

Porcellaneous and pearly shells compared. When the experiments on the porcellaneous shells, and on those formed of mother of pearl, are compared, it appears, that the porcellaneous shells are composed of carbonat of lime, cemented by a very small portion of gluten; and that mother of pearl, and pearl, do not differ from these, except by a smaller proportion of carbonat of lime; which, instead of being simply cemented by animal gluten, is intermixed with, and serves to harden a membranaceous or cartilaginous substance; and this substance, even when deprived of the carbonat of lime, still retains the figure of the shell.

But between these extremes, there will probably be found many gradations, and these we have the greater

reafon to expect, from the example afforded by the patellæ.

Hatchett having ftated the difference between porcellaneous fhell and mother of pearl, thinks it is not poffible to avoid the comparing of thefe to enamel and tooth. Porcellaneous fhell compared with enamel and tooth.

When porcellaneous fhell, whole or in powder, is expofed to the action of acids, it is completely diffolved, without leaving any refiduum; and enamel is alfo completely diffolved in the like manner.

Porcellaneous fhell and enamel, when burned, emit little or no fmoke, nor fcarcely any fmell of burned horn or cartilage. Their figure, after expofure to fire, is not materially changed, except by cracking in fome parts; their external glofs partly remains, and their colour at moft becomes gray, very different from what happens to mother of pearl, or tooth. In their fracture, they have a fibrous texture; and in fhort, the only effential difference between them appears to be, that porcellaneous fhells confift only of carbonat of lime, and enamel of phofphat of lime, each being cemented by a fmall portion of gluten.

In like manner, if the effects produced by fire and acid menftrua, on fhells compofed of mother of pearl, and on the fubftance of teeth and bone, are compared, a great fimilarity will be found; for when expofed to a red heat, Mother of pearl with bone and tooth.

1ft. They fmoke much, and emit a fmell of burned cartilage, or horn.

2d. They become of a dark gray or black colour.

3d. The animal coal thus formed is of difficult incineration.

4th. They retain much of their original figure; but the membranaceous fhells are fubject to exfoliate.

5th. Thefe fubftances (pearl, mother of pearl, tooth, and bone) when immerfed in certain acids, part with their hardening or offifying fubftances, and then remain in the ftate of membrane or cartilage.

6th. When previoufly burned, and afterward diffolved in acids, a quantity of animal coal is feparated, according to the proportion of the gelatinous, membranaceous, or cartilaginous fubftance, and according to the duration of the red heat.

And laftly, the acid folutions of thefe fubftances, by proper precipitants, afford carbonat of lime in the one cafe, and phofphat principally in the other, in a proportion relative to the membrane or cartilage, with which, or on which, the one or the other had been mixed, or depofited.

As porcellaneous fhell principally differs from mother of pearl, only by a relative proportion between the carbonat of lime, and the gluten, or membrane, in like manner, the enamel appears only to be different from tooth or bone, by being deftitute of cartilage, and by being principally formed of phofphat of lime, cemented by gluten.

The difference in the latter cafe feems to explain why the bones and teeth of animals fed on madder became red; when at the fame time, the like colour is not communicated to the enamel; for it appears probable, that the cartilages which form the original ftructure of the teeth and bones, become the channels by which the tingeing principle is communicated and diffufed. Thefe comparative experiments prove, that there is a great approximation in the nature of porcellaneous fhell and the enamel of teeth, and alfo in that of mother of pearl and bone; and if a fhell fhould be found compofed of mother of pearl, coated by the porcellaneous fubftance, it will refemble a tooth coated by the enamel, with the

difference of carbonat being fubftituted for the phofphat of lime.

Some few experiments were made on certain land fhells; and in that of the common garden fnail this chemift thought he difcovered fome traces of phofphat of lime, but as he found none in the helix nemoralis, it may be doubted whether the prefence of the phofphat of lime fhould be confidered as a chemical character of land fhells. Snail fhells.

Experiments on the fubftance, called the bone of the cuttle fifh, proves, that it is exactly fimilar to fhell in compofition, and confifts of various membranes, hardened by carbonat of lime, without the fmalleft mixture of phofphat; and of courfe is improperly called a bone. Bone of the cuttle fifh.

CRUSTACEOUS PARTS.

Cruftaceous parts.

HATCHETT not being acquainted with any experiments, by which the chemical nature of the fubftance which covers the different cruftaceous marine animals, as the echini, ftar fifh, crabs, lobfters, &c. had been determined, was defirous to afcertain in what refpect it differed from fhell; and he began his experiments on three fpecies of echinus. He was the more inclined to begin with the echini, becaufe naturalifts do not appear to be perfectly agreed, whether to call them teftaceous or cruftaceous animals; for Klein, who has written a book upon them, regards them as belonging to the firft tribe; whilft Linnæus, on the contrary, looked upon them as of the fecond. Now, as the experiments above related had proved that the fhells of marine animals were compofed of carbonat of lime, without any phofphat, this chemift thought it very poffible, that

the covering of the cruftaceous animals might, in fome refpect, be different; and if fo, he might be enabled, by chemical characters, to afcertain the clafs to which the echinus was to be referred.

Echini. Of the three echini examined, one had fmall fpines; the fecond had large obtufe fpines, and the third was of a very flat form.

Portions of thefe echini were feparately immerfed in acetous, muriatic, and diluted nitric acid, by each of which they were completely diffolved, with much effervefcence, depofiting at the fame time a thin outer fkin or epidermis. The tranfparency of the folutions was alfo difturbed by a portion of gluten, which remained fufpended, and communicated a brownifh colour to the liquors.

The folutions in acetous and diluted nitric acids were filtered; after which, from the acetous folution of each echinus, a precipitate of phofphat of lead was obtained, by the addition of acetite of lead; and having thus proved the prefence of phofphoric acid, the nitric folutions were faturated with pure ammonia, by which a quantity of phofphat of lime was obtained, much inferior, however, in quantity to the carbonat of lime, which was afterward precipitated by carbonat of ammonia.

The compofition of the cruft of the echinus is therefore different from that of marine fhells, and by the relative proportions and nature of the ingredients, it approaches moft nearly to the fhells of the eggs of birds; which, in like manner, confift of carbonat, with a fmall proportion of phofphat of lime, cemented by gluten.

Afterias. It remained now to examine the compofition of thofe fubftances, which are decidedly called cruftaceous; but previous to this, fome experiments were made on the afterias, or ftar fifh, and that fpecies was ufed which is commonly found on our coafts, known by the com-

mon name of five fingers, or the afterias rubens of Linnæus.

When the afterias was immerfed in the acids, a confiderable effervefcence was produced, and a thin external ftratum was diffolved ; after which, it remained in a perfectly coriaceous ftate, and complete, in refpect to the original figure. The diffolved portion, being examined by the ufual precipitants, proved to be carbonat of lime, without any mixture of phofphat ; but in another fpecies of the afterias, with twelve rays, or the afterias pappofa of Lin. a fmall quantity of phofphat of lime was difcovered. This chemift was therefore induced to fufpect, that in the different fpecies of afterias, nature makes an imperfect attempt to form fhell on fome, and a cruftaceous coating on others ; and that a feries of gradations is thus formed between the teftaceous, the cruftaceous, and the coriaceous marine animals.

Crab, lobfter, prawn, and crayfifh.

It was now requifite to afcertain, whether phofphat of lime were a component part of the fubftance which covers the cruftaceous, marine, or aquatic animals; fuch as the crab, lobfter, prawn, and crayfifh.

Pieces of this fubftance, taken from various parts of thofe animals, were at different times immerfed in acetous, and in diluted nitric acid; thofe which had been placed in the diluted nitric acid produced a moderate effervefcence, and in a fhort time were found to be foft and elaftic, of a yellowifh white colour, and like a cartilage which retained the original figure. The fame effects were produced by acetous acid, but in a lefs degree; in the latter cafe alfo, the colouring matter remained, and was foluble in alcohol.

All the folutions, both acetous and nitric, afforded carbonat and phofphat of lime, although the former was in the largeft proportion.

Cruftaceous, compared with teftaceous fubftances.

There is reafon to affirm, therefore, that phofphat of lime, mingled with the carbonat, is a chemical characteriftic, which diftinguifhes the cruftaceous from the teftaceous fubftances, and that the principal difference in the qualities of each, when complete, is caufed by the proportion of the hardening fubftance, relative to the gluten, by which they are cemented; or by the abundance and confiftency of the gelatinous, membranous, or cartilaginous fubftance, in and on which, the carbonat or the mixture of carbonat and phofphat of lime, has been fecreted and depofited. Moreover, as the prefence of phofphat of lime, mingled with carbonat, appears to be a chemical character of cruftaceous marine animals; there is every reafon to conclude, that Linnæus did right not to place the echini among the teftaceous ones.

The prefence of phofphat of lime, in the fubftance which covers the cruftaceous marine animals, appears to denote an approximation to the nature of bone; which not only by the experiments of Gahn, but by the united teftimony of all chemifts, has been proved principally to confift (as far as the offifying fubftance is concerned) of phofphat of lime.

Conclufion.

By the experiments on various fhells, cruftaceous fubftances, and bones, it is therefore proved according to Hatchett,

1. That the porcellaneous fhells refemble the enamel of teeth in the mode of formation, but that the hardening fubftance is carbonat of lime.

2. That fhells compofed of nacre, or mother of pearl, or approaching to the nature of that fubftance, and alfo pearls, refemble bone in a confiderable degree, as they confift of a gelatinous, cartilaginous, or membranaceous fubftance, forming a feries of gradations, from a tender and fcarcely perceptible jelly, to membranes completely organized, in and upon which, carbonat of lime is

ſecreted and depoſited after the manner that phoſphat of lime is in the bones; and therefore as the porcellaneous ſhells reſemble the enamel of teeth, ſo the ſhells formed of mother of pearl, &c. in like manner, reſemble bone; the diſtinguiſhing chemical character of the ſhells being carbonat of lime, and that of enamel and bones being phoſphat of lime.

3. That the cruſt which covers certain marine animals, ſuch as crabs, lobſters, crayfiſh, and prawns, conſiſts of a ſtrong cartilage, hardened by a mixture of carbonat and phoſphat of lime; and that thus theſe cruſtaceous bodies occupy a middle place between ſhell and bone, although they incline principally to the nature of ſhell.

4. And laſtly, that a certain proportion of carbonat of lime enters the compoſition of bones in general; the proportion of it, however, being to the phoſphat of lime, *vice verſa*, to that obſerved in the cruſtaceous marine ſubſtances. Upon the view, therefore, of theſe facts, it is evident, that there is a great ſimilarity in the conſtruction of ſhell and bone, and that there is even an approximation in the nature of their compoſition, by the intermediate cruſtaceous ſubſtances.

Zoophytes.

ZOOPHYTES.

Examined by Bouvier and Durande.

The component parts of the zoophytes were but little known before the experiments of Hatchett. Bouvier had, however, made an analyfis of the *corollina officinalis*; and Durande had fomewhat inveftigated *corollina fubpinnata*. The firft found, that 1000 grains of the *c. offic.* were compofed of,

1.	Muriat of foda	10
2.	Gelatin	66
3.	Albumen	64
4.	Sulphat of lime	19
5.	Silex	7
6.	Iron	2
7.	Phofphat of lime	3
8.	Magnefia	23
9.	Lime	420
10.	Carbonat of lime	196
11.	———— magnefia ..	51
12.	Water	141
		1002

The latter procured, on diftillation of the c. fubpin., volatile alc. with phlegm, and an oil, and found the earth to be calcareous; he looks upon it as a plant impregnated with a large quantity of calcareous earth and animal matter.

Preliminary obfervations by Hatchett.

Hatchett, in his experiments upon the different genera of zoophytes, adopted a fimilar mode to that which he employed in his experiments, before mentioned in this article. He obferves, however, that as argill is not un-

frequently lodged, as an extraneous fubftance in the interftices of many of the madrepores, and fuch like bodies; and as argill is precipitated by pure ammonia, it was neceffary, not to rely merely on the ammonia, as a teft of phofphat of lime. Wherever, therefore, any precipitate was produced by ammonia, it was diffolved again in acetous acid, and this folution was examined by the addition of acetite of lead.

It appears that the minutiæ of analyfis in the experiment did not form part of his plan, which was only to fketch an outline, comprehending the moft prominent chemical characteriftics of certain bodies belonging to the animal kingdom, which hitherto had been but little or not at all examined; fo that this outline, although defective, might ferve as a chain of connection, and as a bafis, upon which a more perfect fuperftructure may in future be gradually raifed; and it appeared to him, that this would be moft fpeedily and eafily executed by following a fyftematic and comparative plan. For this reafon a great part of his attention was directed towards afcertaining, in thefe animal fubftances, the prefence and general proportions of carbonat and phofphat of lime; thefe being the materials effentially employed by nature to communicate rigidity and hardnefs to certain parts of animals, fuch as fhell and bone; and although fome other fubftances, as magnefia, filex, iron, and fome alkaline and neutral falts, might be occafionally prefent in fmall proportions, (and indeed were at times detected) yet, as they appear to have but little influence on the general characters of the bodies which were examined, he did not think proper to take particular notice of them. The next object was, to examine the nature of the fubftance in and upon which the hardening or offifying principles were fecreted and depofited; and it appeared to him the beft mode of performing it was to compare and examine this fubftance in the

various ſtates in which it appeared, when deprived of the hardening or oſſifying matter.

From what Hatchett has ſaid on ſhell and bone, concerning the ſubſtance which remained after the carbonat of lime in ſhells, and after the phoſphat of lime in bones, had been diſſolved and ſeparated by weak acids, it is evident, that the ſubſtance which thus remains is as various in relative quantity, as it is in thoſe qualities which apparently are produced by the degrees of natural inſpiſſation, and by the progreſſive effect of organization. In the porcellaneous ſhells, ſuch as *cyprea*, &c. this ſubſtance he proved to be much leſs in quantity than in thoſe which were afterwards mentioned, and although of a quality which, (like a cement or gluten) ſeemed to bind and connect the particles of carbonat of lime firmly together, ſo ſmall was the degree of natural inſpiſſation, and ſo little advanced was the degree of organization, that, when the carbonat of lime was diſſolved, even by very feeble acids, little or no veſtige of jelly, membrane, or cartilage, could be perceived; nor indeed could any be detected, but by the ſmall portion of animal coal which was formed, when theſe ſhells had been expoſed for a ſhort time to a low red heat.

But proceeding from ſhells of this deſcription to others tending to the nature of nacre or mother-of-pearl, (ſuch as ſome of the *patellæ*) a ſubſtance was left *untouched by the acids*, which had the appearance of a yellowiſh tranſparent jelly; ſo that the ſubſtance, which ſerved merely as a gluten in the porcellaneous ſhells, was not only more abundant in the *patellæ*, but, being more inſpiſſated, was become immediately viſible and palpable.

In the common oyſter, the qualities were more ſtrongly marked; and in the river muſcle, and in the ſhells compoſed of the true nacre or mother-of-pearl, this ſubſtance was found not only to conſtitute a large part of the ſhell,

but even to be more denfe, fo as no longer to appear gelatinous; and, in addition to thefe, ftrong and vifible marks of organization were ftamped on every part, and a perfect membranaceous part remained, compofed of fibres arranged parallel to each other, according to the configuration of the fhells.

From the facts proved by the examination of only a very few (comparatively fpeaking) of the known fhells, it appears, that the hardening principle or carbonat of lime, together with a fubftance varying from a very attenuated gluten to a tough jelly, and from this to a perfectly organized membrane, concur to form the matter of fhell; and from the refult of the experiments, and from all circumftances, there is every reafon to believe, that the fubftance with which, or upon which, the carbonat of lime is mixed or depofited, is of a fimilar nature, and differs only in relative quantity or denfity, arifing from progreffive changes (peculiar to the various fpecies of fhells) produced by certain degrees of natural infpiffation, and by an organization more or lefs perfect.

The experiments made on teeth and on the bones of various animals, elucidated and confirmed the obfervations made on the nature of fhell; for,

1. The enamel of teeth (in relation to the other bony fubftances) was proved to be, as the porcellaneous fhells are to thofe formed of mother-of-pearl; the cementing fubftance of enamel being a gluten, in the fame ftate and apparently of a fimilar nature with that of the porcellaneous fhells. And,

2. In certain bones, particularly thofe of fifh, (fuch as fome of the bones of the fkate) the fubftance, which remained after the folution of the phofphat of lime, was of a gelatinous confiftency, and exhibited but very imperfect traces of organization; by the others, however, a com-

pletely formed membrane, or cartilage, was left, retaining the figure of the original bone.

When, therefore, the component parts of ſhell and bone are conſidered, it appears, that the eſſential characteriſtics are, carbonat of lime for the one, and phoſphat of lime for the other; and that their baſes conſiſt of the modifications of a glutinous, gelatinous, or membranaceous ſubſtance. The term jelly Hatchett only employs to denote the degree of conſiſtency of this ſubſtance, which, in it's nature, is very different from the varieties of animal jelly called gelatin.

Having traced the progreſſive and connected changes in the compoſition of the various ſhells and bones, Hatchett found his obſervations on thoſe bodies corroborated, and the chain of connection extended, by the developement of the facts reſulting from his experiments on zoophytes; and, having made the preliminary obſervations, it will be now proper to take a view of theſe experiments, and to examine how far they tend to prove, that the ſubſtances are all of a nature cloſely connected.

His experiments on madrepores.

The *madrepora virginia,* when immerſed in very dilute nitric acid, efferveſced much, and was ſoon diſſolved. The ſolution was perfectly tranſparent and colourleſs, with but a ſmall appearance of gelatinous or membranaceous particles. Pure ammonia was then added, but produced no change, and the whole of what had been diſſolved, was afterwards completely precipitated by carbonat of ammonia, and proved to be carbonat of lime. The *muricata* and the *labyrinthica* afforded looſe portions of a tranſparent gelatinous ſubſtance. *M. ramea* and *m. faſcicularis,* when deprived of the carbonat of lime by acids, remained in the ſtate of completely organized and membranaceous bodies, which exhibited the original figure of

the refpective madrepores; and the proportion of coal, afforded by them, was more abundant than what was obtained from the firft mentioned.

Millepora cerulea. This produced much effervefcence in very dilute nitric acid. The blue colour difappeared as the calcareous part was diffolved, and was not afterwards reftored by ammonia. It afforded loofe detached portions of a gelatinous fubftance. Millepores.

M. alcicornis yielded the fame, but in a more coherent ftate; but it did not retain the figure of the millepore. *M. polymorpha* remained unchanged in fhape, and confifted of a ftrong, white, opake membrane, filled with a tranfparent jelly. Ammonia produced a very flight precipitate from the folution in nitric acid, which, being diffolved in acetous acid, was proved to be phofphat of lime, by folution of acetite of lead. Carbonat of foda afterward precipitated a large quantity of carbonat of lime. Laftly, *m. cellulofa*, *m. fafcialis*, and *m. truncata* afforded membranaceous bodies in a complete ftate of organization, and all the *madrepores* and *millepores*, when expofed to a low red heat in a crucible, emitted fmoke, with the fmell of burned horn or feathers, became tinged of a pale or deep gray colour, and, when diffolved in acids, depofited more or lefs animal coal, in proportion to the quantity of the gelatinous or membranaceous fubftance detected by the above experiment.

The univerfal and only hardening principle of thefe *madrepores* and *millepores* was proved to be carbonat of lime, with the fingle exception of *millepora polymorpha*, which alfo appears to be differently conftructed from the other *millepora*; with this fingle exception, carbonat of lime feems to be the only hardening fubftance in thefe bodies, and, when every circumftance is confidered, an exact fimilarity is to be found between the fubftance forming the various fhells, and that which forms the *madreporæ* and

milleporæ; and the nature of thefe bodies is fo completely the fame, that the changes or gradations of the one are to be found in the other. For the chemical characters which diftinguifh the porcellaneous fhells are in a great meafure approached by thofe of *madrepora virginia*, and thofe which are noticed in the *patellæ* correfpond precifely with the madrepores and millepores, which afford a gelatinous fubftance; and, laftly, the characters of the membranaceous part, exhibited by the fhells formed of nacre or mother-of-pearl, are in like manner to be found among fome of the madrepores and millepores; fuch as *madrepora ramea, millepora fafcialis, m. truncata*; for thefe, like the *turbo clearius* and *haliotis iris*, are compofed of a fibrous membrane, hardened by carbonat of lime.

It appears therefore, that the madrepores and millepores, like the various fhells, are formed of a gelatinous or membranaceous fubftance, hardened by carbonat of lime, and the only difference is in the mode according to which the materials have been employed.

Tubiporæ. Of the tubiporæ he had only an opportunity of examining the *tubipora mufica*. Like the former fubftances, it was immerfed in an acid, and, on this occafion, he employed the acetous acid. A great effervefcence was produced, and the red colour was deftroyed; in proportion as the calcareous part was diffolved, fome loofe particles of a tender membrane floated in the liquor. Pure ammonia produced a precipitate of argill, accidentally lodged in the interftices of the tubipore. From the filtrated liquor, carbonat of potafh precipitated a large quantity of carbonat of lime.

Fluftra. When the *fluftra foliacea* was immerfed in very dilute nitrous acid, an effervefcence of fhort duration took place, and when this had ceafed, the *fluftra* appeared like a finely reticulated membrane, which retained the original fhape. Pure ammonia, added to the filtrated folution, produced

a ſlight precipitate, which, diſſolved in acetous acid, was found by acetite of lead to be phoſphat of lime. On adding afterwards a ſolution of carbonat of ammonia, a copious precipitate of carbonat of lime was produced. When the fluſtra foliacea was expoſed to a low red heat in a crucible, it emitted a ſmell like burned horn, but retained its ſhape, by reaſon of the carbonat of lime, with which it was coated. The fluſtra, thus burned and diſſolved in dilute nitric acid, depoſited ſome animal coal; but in other reſpects, the preſent ſolution reſembled the former nitric ſolution of this ſubſtance, when in a recent ſtate. When the fluſtra foliacea was long digeſted with boiling diſtilled water, it communicated to it a pale browniſh tinge. Infuſion of oak bark, being poured into the liquor, did not produce any viſible effect, even after 24 hours had elapſed; but nitro-muriat of tin formed a white cloud in a few minutes.

Coralline, like the fluſtra foliacea, produced in very dilute nitric acid an efferveſcence of ſhort duration. The coralline then remained in a membranaceous ſtate, and retained the original figure. Pure ammonia produced ſcarcely any effect. Carbonat of ammonia precipitated a large quantity of carbonat of lime. Some of the coralline was then expoſed in a crucible to a low red heat, when it emitted a ſmell of burned horn, and retained in great meaſure it's ſhape, evidently from the calcareous coating. The burned coralline, diſſolved in dilute nitric acid, depoſited ſome animal coal. The clear ſolution afforded by pure ammonia a very ſlight precipitate of phoſphat of lime, after which the carbonat of lime was precipitated as before. Corallina.

The experiments, therefore, on the *tubipora muſica* prove it's reſemblance, in compoſition, to the ſubſtances before it; but a ſlight difference was obſerved in the hardening ſubſtance of the *fluſtra foliacea* and *corallina opuntia*; for

a ſmall portion of phoſphat was found mixed with the carbonat of lime, as firſt obſerved; but the membranaceous part of theſe bodies reſembles that of certain madrepores and millepores, particularly *millepora faſcialis.*

Iris. When the *iris ochracea* was immerſed in dilute nitric acid, a conſiderable efferveſcence was produced, and, in proportion as the calcareous ſubſtance was diſſolved, the red colouring matter was depoſited in the ſtate of a fine red powder. This colouring ſubſtance was neither diſſolved nor changed, when nitric or muriatic acid was poured upon it. It appears therefore to be very different from the tingeing matter of the *tubipora muſica,* or that of the *gorgonia nobilis.* When the efferveſcence had ceaſed, (in about three hours) a yellowiſh membrane remained, which completely retained the original figure of the iris. A ſlight precipitate of phoſphat of lime was ſeparated from the filtrated ſolution, when ſaturated with pure ammonia. A large quantity of carbonat of lime was afterward precipitated by carbonat of potaſh.

Part of a branch of this iris was expoſed to a low red heat; it ſmoked and ſmelled like burned horn, and, in a few minutes, the branch ſeparated at the knotty joints into as many pieces as there were joints in the branch. Theſe joints had all the character of coal; but the whole of the membrane, which had inveſted them, as well as the knotted protuberance, by which they had been connected, were deſtroyed, by being converted into coal. From this Hatchett was deſirous to examine the internal ſtructure of the membranaceous part, out of which theſe joints of coral had been diſſolved by acids. He therefore took the membranaceous ſubſtance, which retained the complete figure of the iris; and this, being opened longitudinally, exhibited a ſeries of cavities, correſponding in form with the coralline joints, and ſo ſituated, that each of theſe cavities extended from one bulb, or knot, nearly

to the next, throughout the whole of the branch. The coralline joints, when viewed ſeparately, appeared ſmaller in the middle than at the ends, which were terminated by obtuſe cones. In the branch theſe joints were ſo placed, that the extremities or cones were oppoſed point to point, but were prevented from immediate contact by a griſtly ſubſtance, which filled, and, indeed, principally formed in the branch the knot or knob of each joint, and was interpoſed between the cones of the coralline ſubſtance, like the common cartilage of the articulations. From this conſtruction it appears, that this iris is capable of great flexibility when in a recent ſtate; for the griſtly part of the bulbs is then, moſt probably, much ſofter and more elaſtic than the dried ſpecimens. The griſtly ſubſtances, which form the bulbs and the coralline joints, are kept together and covered by a thin membrane or ſkin, continued over the whole like a tube. The joints are not therefore devoid of coating, as ſeems implied by the definition of Linnæus. *Iris hippuris* was ſimilar to the above, except poſſeſſing carbonat of lime. A tube of membrane, however, inveſts the curious ſtructure of the before mentioned iris, whilſt in this no ſuch tube or outer coat exiſts; for the coralline joints (like ſome of the madrepores, millepores, &c.) conſiſt of a membranaceous ſubſtance, hardened by carbonat of lime; and the only difference appears to be, that in the madrepores and millepores the membranaceous part is leſs compact and abundant; but even the ſtriæ of the coralline joints remain viſible and unchanged in the membrane of this iris.

The horny part forms alſo a marked characteriſtic in this iris, and ſeems to approach it to certain of the gorgoniæ. This horny part does not, however, pervade the whole of the branch; for where the coralline joints commence, this horny ſubſtance immediately terminates,

internally as well externally, and is not to be discovered but between, or in the separation of, these joints.

Hence both of these irises are formed of regularly organized, membranaceous, cartilaginous, and horny substances, hardened in the last mentioned species merely by carbonat of lime, but in the iris *ochracea* with the addition of a very small portion of phosphat of lime.

Gorgoniæ. He made experiments on different pieces of the *gorgonia nobilis*, or red coral, some of which were polished and deprived of their external pale red mealy coat, whilst others were in their original state. They both afforded carbonat of lime, and the unpolished red coral, whether in diluted nitric acid, or in acetous acid, had it's calcareous part completely dissolved, and there remained an external tubulated membrane of a pale yellow colour, retaining the original figure, and filled with a transparent gelatinous substance. The polished or uncoated red coral, treated in the same manner, left a transparent gelatinous substance like the other, except that it was not in detached portions. This solution, like the former, only yielded carbonat of lime. In each of these experiments the red colour of the coral was gradually destroyed, as the solution of the calcareous substance advanced, and could not afterwards be restored, nor could any colouring principle whatever be detected by the reagents usually employed. When the coated or uncoated coral was exposed to a slow red heat, which produced a smell of burned horn, it had lost it's red colour, and became gray, and being afterwards dissolved in dilute nitric acid, and the precipitate by ammonia again dissolved in acetous acid, phosphat of lead was obtained on the addition of acetite of lead. The carbonat of lime was afterwards precipitated in the usual manner. Hence this gorgonia consists of two parts, one of which is the stem formed of a gelatinous substance, hardened by carbonat of lime, and coloured by some unknown modification of animal matter; the other is a

membranaceous tube, which, like a cuticle or context, coats the ſtem, and when deprived of it's hardening ſubſtance, poſſeſſes all the characters of membrane. But although carbonat of lime could only be diſcovered when this *gorgonia* was ſimply immerſed in acids, yet it appears a ſmall portion of phoſphat of lime is alſo preſent, but ſo enveloped by the membranaceous and gelatinous parts, as not to be diſſolved by the acid menſtrua, till theſe ſubſtances have been decompoſed by fire. This is not an unuſual circumſtance, when a very ſmall portion of a ſubſtance is enveloped by large quantities of other matter; for Bergman obſerves it, with reſpect to the *calculus veſicæ*, in his ſupplement to Scheele's eſſay. Hatchett does not, however, pretend to determine, whether the very ſmall portion of phoſphat of lime in this gorgonia be an eſſential ingredient or not, but the mode of conſtruction evidently proves how much this gorgonia differs from the madrepores and millepores, as well as from the following gorgonia, *G. ceratophyta*. It efferveſced in dilute nitric acid, after which ſolution the cortical part appeared like a thin yellowiſh membrane, inveſting the ſtem, which was become tranſparent and ſimilar to cartilage. The ſolution afforded a large quantity of phoſphat of lime by ammonia, and lixivium of potaſh ſeparated ſome carbonat of lime. The cortex ſcarcely afforded a veſtige of phoſphat of lime, but a conſiderable quantity of carbonat. On the contrary, the ſtem afforded the phoſphat in large quantity and very little of the laſt. When burned in a crucible, it ſmelled like burned horn, but the figure was not deſtroyed; and when afterwards diſſolved in the acid, it yielded the ſame product as before. *G. flabellum*. In dilute nitric acid it's efferveſcence was ſhort, and the cortical part appeared like a thin yellowiſh membrane, which covered the ſtem. The latter was tranſparent, and reſembled ſoftened horn of a reddiſh brown colour. The ſolution afforded a large

quantity of phofphat of lime, and a lefs copious precipitate of carbonat. The folution of the cortex was fcarcely rendered turbid by ammonia; but afforded a confiderable portion of carbonat of lime by potafh. The ftem, from which the cortical part was taken, being fteeped three days in diluted nitric acid, became foft, elaftic, and, in fome meafure, cartilaginous: it contained a deal of phofphat, but very little carbonat of lime. The recent ftem, in great meafure, retained it's fhape when put into a red hot crucible; but that which had been fteeped in the acid curled up, and foon became a fhapelefs mafs of coal, which by a longer heat was completely diffipated. This difference appears to have been caufed by the phofphat of lime, prefent in the recent ftem, but diffolved and feparated in the latter cafe by the acid. Hatchett obferves likewife, that the different effects are to be obferved, when bone and when the cartilage or membrane, which remains after bone has been long fteeped in acids, are expofed to a red heat.

Thefe experiments prove, that the *G. flabellum*, like the *G. ceratophyta*, confifts of a horny ftem, containing a certain proportion of phofphat of lime, and that this ftem is invefted with a membrane, hardened principally by carbonat of lime, which feems to cover and defend it in the manner of a fhell. *G. fuberofa*. The cortical part being feparated from the ftem was firft fubjected to experiment. In dilute nitric acid, after an effervefcence of feveral hours, a foft yellowifh membranaceous fubftance remained, retaining the original figure. The folution contained a little phofphat of lime, and a large portion of the carbonat. Some of the pieces of the cortex, boiled in diftilled water fix hours, afforded a great deal of gelatin by means of infufion of oak bark. The fame pieces afterward boiled with lixivium of cauftic potafh were diffolved, and formed the animal foap of Chaptal; the cal-

careous part fubfided to the bottom. The cortical part expofed in a red hot crucible, fmelled like burned horn, and fell to pieces, which, being diffolved in nitric acid, gave a little phofphat and a great deal of the carbonat of lime. The ftem, on being fteeped fourteen or fifteen days in the dilute acid, tinged it of a pale yellow. After this, the ftem was more tranfparent and flexible, approaching to cartilage; ammonia changed the yellow liquor to a deep yellow or orange colour; but there was no precipitate, even when carbonat of potafh was added. Part of a ftem, cut in fmall pieces and boiled in water, afforded gelatin in fmall quantity, and cauftic potafh formed with it Chaptal's animal foap. The ftem, in a red heat, curled up and fmelled like horn, and by a long continuation of the heat, the fcarcely to be collected refiduum diffolved in dilute acid, gave by ammonia a flight portion of phofphat of lime. Another fpecies, which moft refembled the *fuberofa*, except that the cortical part was much longer in proportion to the ftem, proved to be of a fimilar compofition with the above. *G. pectinata*. The cortical part gave a little phofphat of lime and a large portion of carbonat. The ftem refembled thofe defcribed. *G. fetofa* effervefced in dilute nitric acid, and after fome hours, the cortical part appeared a thin yellowifh membrane, which coated the horny ftem. The folution contained a flight portion of phofphat and a large one of carbonat of lime. When the cortex was feparately fteeped in the acid, and the folution examined as before mentioned, only carbonat was obtained. On the contrary, the ftem, whether recent or burned, gave a little phofphat, but fcarcely any trace of carbonat. The ftem became in the acid foft and tranfparent, like cartilage. Thus the gorgoniæ already enumerated refemble each other much in the compofition of their cortices, as well as in the nature of their ftems. In the cortex the

predominant hardening ſubſtance is carbonat of lime; but, in the ſtem, phoſphat of lime is the chief, and almoſt the only earthy ſubſtance that is préſent.

The following *gorgoniæ*, although inveſted alſo with a cortex, are different, as they do not afford any phoſphat of lime. The *g. umbraculum*, *verrucoſa*, and three other ſpecies not deſcribed, nearly reſemble each other. Their cortical parts in dilute acid effervefced, and became ſoft, pulpy, yellowiſh white membranaceous bodies, with nearly their original form and ſize. The acid ſolutions gave no phoſphat, but a large proportion of carbonat of lime. The ſtems, left fourteen days in the acid, were very little affected, except becoming ſoft and tranſparent, reſembling cartilage or ſoftened horn; and they became of a deep reddiſh orange colour, inclining to brown, in pure ammonia, and in a few hours were completely diſſolved. The acid, in which they were ſteeped, afforded no precipitate.

The remaining *gorgoniæ* differ from the former, as they are not coated with a fleſhy or pulpy cortical ſubſtance. They are here placed immediately before the *antipathes*, on account of their great ſimilarity in chemical properties as well as in external appearance. *G. antipathes*. Some pieces of this gorgonia were immerſed in dilute nitric acid during three weeks, in which they became ſoft, and appeared to be compoſed of a pale brown, opake, membranaceous ſubſtance, which formed concentrical coats of a ligneous aſpect. The acid was become pale yellow, and ammonia changed it to orange colour; but neither it nor potaſh produced any precipitate. The gorgonia boiled ſix hours in diluted water tinged it yellow, and, on adding infuſion of oak bark, a ſmall portion of gelatin was precipitated. The pieces thus treated formed a dark coloured animal ſoap with cauſtic potaſh. The gorgonia expoſed to a red heat, ſwelled like burned horn, ſoon loſt

it's ſhape, puffed up, and formed a ſpongy coal, which by a long continued heat left a few particles of a white ſubſtance, chiefly muriat of ſoda. *Another ſpecies* of gorgonia was then examined, the ſtem of which is from a quarter to nearly half an inch in diameter in the thickeſt part, of a black colour, high poliſh, like black ſealing-wax, and has probably been conſidered a variety of the *G.* antipathes. On immerſion 28 days in dilute acid, it gradually became tranſparent, of a bright browniſh yellow. In this ſoft ſtate it was ſteeped two days in water, and then opened longitudinally. By this the whole ſtructure became apparent, and conſiſted of thin coats or tubes of a beautiful tranſparent membrane, which progreſſively became larger, according to the order in which they receded from the centre. Theſe membranes were ſo delicate, that the fibrous texture could ſcarcely be diſcerned. The acid was tinged a very pale yellow, and ammonia changed it to a deep yellow or orange, but produced no change of tranſparency, or any precipitate. Expoſed to a red heat, this gorgonia crackled, emitted a ſtrong ſmoke, and ſmelled like burned horn. The ſhape was ſoon deſtroyed, and a compact coal remained. On incineration, a little white matter was obtained, and proved to be muriat and a little carbonat of ſoda. The *laſt ſpecies* of gorgonia which Hatchett inveſtigated is not eaſily to be diſtinguiſhed from the g. antipathes; but, upon a cloſe compariſon, this now treated of is more flat in the ſtem, on the thin ſides or edges of which a number of ſhort ſpines or protuberances are placed very near each other. That it is very different from the g. antipathes the following will prove. On expoſure to dilute acid for nearly four weeks, the ſtructure became apparent, and conſiſted of ſtrong fibres, nearly in a parallel direction from one extremity of the branch to the other, and being cloſely arranged ſide by ſide, formed concentric coats of a pale

brown opake fubftance; but thefe coats were by no means fo diftinct as thofe obferved in the former gorgoniæ, although, like them, the fibrous fubftance poffeffed the character of membrane. The dilute acid was pale yellow, changed by ammonia to orange; and fo large a quantity of phofphat of lime was precipitated, as to make the liquor thick and vifcid. The phofphat being feparated by a filter, the lixivium of potafh had no effect on the clear liquor. The gorgonia, digefted in boiling diftilled water eighteen hours, tinged it pale yellow, and oak bark precipitated a little gelatin from it. The pieces employed, boiled with lixivium of cauftic potafh, formed a dark coloured animal foap; phofphat of lime was feparated, and gradually fell to the bottom of the matrafs. Part of a large branch expofed to a low red heat, fmelled like burned horn, and being long continued, the phofphat of lime was left, fo as to retain the original figure, like bone which has been burned, but the particles of the mafs cohered but feebly. The refiduum being diffolved, and the phofphat feparated, a flight cloud of carbonat of lime was produced by potafh.

It therefore appears on recapitulation, from the above experiments on the various fpecies of gorgonia, that the hardening fubftance of the *g. nobilis* (which was formerly looked upon as an iris) was found to be carbonat of lime, with a fmall portion of phofphat; but the matter forming the membranaceous part was (like that of millepora polymorpha) in two ftates; that of the interior being gelatinous, and that of the external part being a membrane completely formed, fo as to cover the fame, as a tube. The refults of the experiments on the *g. ceratophyta, flabellum, fuberofa, pectinata*, and *fetofa*, were remarkable; for, when the two parts which compofe thefe *gorgoniæ*, viz. the horny ftem and the cortical fubftance, were feparately examined, it was proved,

1. That the ftems of thefe gorgoniæ confift of a fubftance analogous to horn, and that by long maceration in diluted nitric acid, this horny fubftance becomes foft and tranfparent, fo as to refemble a cartilaginous or tendinous body ; likewife the ftems afford a quantity of phofphat of lime, but fcarcely any trace of carbonat.

2. That the cortical part, on the contrary, confifts principally of carbonat of lime, with very little or none of the phofphat; and the carbonat of lime is depofited in and upon a foft, flexible, membranaceous fubftance, which feems much to approach the nature of cuticle.

Some of the gorgoniæ fubfequently examined, refembling the former in conftruction, did not yield any phofphat of lime, but in every other refpect were fimilar. The *G. antipathes* was found to be entirely formed of a fibrous membrane ; and the *black fhining polifhed gorgoniæ*, afforded by maceration a moft beautiful fpecimen of membranes, concentrically arranged. Laftly, the *gorgonia* Hatchett defcribed as very much like the G. antipathes proved to be fimilar to that fpecies, as to the membranaceous part ; but fo large a portion of phofphat of lime was mixed with it as almoft to approach it to the nature of ftag's or buck's horn ; there is, therefore, great reafon to confider it as a different fpecies.

When the *antipathes ulex* had been immerfed fourteen **Antipathes.** days in dilute nitric acid, it became tranfparent, and fo much foftened, that from a horny fubftance it now nearly refembled cartilage. Ammonia changed the acid to an orange colour, but produced no precipitate, neither did potafh. A portion of the antipathes, digefted in diftilled water, afforded gelatin. Boiled with cauftic potafh, it formed the animal foap. *A myriophylla* afforded the fame refults. The fpecimens were fmall, which prevented him from making additional experiments; but thofe already cited,

fufficiently prove, how much the antipathes refemble the horny ftems of the gorgoniæ.

Sponges. Many fpecies of *fponges* were examined, but as little or no effential difference was found in the refults, they may be all included in the following account. The following fpecies, with many others not defcribed, were inveftigated. *Spongiæ cancellata, oculata, infundibuliformis, palmata, officinalis.* When they had been immerfed in nitric acid, diluted with three meafures of diftilled water, for fourteen or fixteen days, the acid became pale yellow, and pure ammonia changed it to an orange colour. The fponges thus fteeped became more or lefs tranfparent, (like the gorgoniæ) and were confiderably foftened. In this ftate, the part touched with ammonia became of a deep orange colour inclining to a brownifh red, and when much foftened by the acid, (if afterward immerfed in ammonia) they formed a complete deep orange-coloured folution, and the fame were obferved of the horny ftems of the gorgoniæ, antipathes, &c. When digefted with boiling diftilled water, the fponges afforded a portion of gelatin, which was precipitated by infufion of oak bark. The fine and more flexible fponges gave it in greater abundance, and more eafily than the coarfe or rigid ones. The gelatin was gradually and progreffively imparted to the water, and in proportion as they were deprived of it, they became lefs flexible and more rigid, fo that the remaining part, when dry, crumbled between the fingers, or when moift, was torn eafily like wetted paper.

As thefe properties prove, that fponges only differ from the horny ftems of the gorgoniæ, and from the antipathes, by being of a finer and more clofely-woven texture; (this is particularly obfervable on comparing the coarfe fponges, as S. cancellata, with the finely

reticulated parts of certain gorgoniæ, especially those of G. Flabellum, when divested of the external membrane) so this similarity will be corroborated by the following remarks. When exposed to heat, they afforded the same products, the same smell, and a similar coal, which, by incineration, left a very small residuum, chiefly of muriat of soda, occasionally mixed with some carbonat of lime, which was also often discovered when the recent sponges were immersed in acids; but this, as well as muriat of soda, is, according to Hatchett, merely extraneous, and arises from small shells, parts of madrepores and such like bodies, which are often visibly lodged in the interstices of the sponges. Lastly, the sponges, when boiled with lixivium of caustic potash, were completely dissolved, and, like the horny stems of the gorgoniæ, formed animal soap, more especially when the part which is apparently insoluble in water, and which remains after the gelatin has been separated, was thus treated.

This series of experiments, made by Hatchett, terminated with an examination of a few species of *alcyonium*, viz. *asbestinum*, *ficus*, and *arboreum*, all of which were found to be composed of a soft, flexible, membranaceous substance, very similar to the cortical part of some of the *gorgoniæ* (or g. suberosa), and in like manner slightly hardened by carbonat, mixed with a small portion of lime, as the following facts will prove. Alcyonium.

Alcyonium asbestinum was unchanged in figure, after remaining several hours in dilute nitric acid; there was a feeble effervescence, and the reddish purple was destroyed. The external part became pale yellow, and was a soft, opake, pulpy substance, within which was a stem, similar in texture, but less soft, and which still appeared of a pale red colour. Ammonia produced no effect on the filtered solution; carbonat of potash precipitated a large quantity

of carbonat of lime. A piece in a low red heat ſoon took fire, and melted like burned horn; after which, it retained it's figure, and became white. Diſſolved in dilute acid, ſome animal coal was depoſited, and ammonia precipitated a little phoſphat of lime; after which, the carbonat was procured. A quantity of gelatin was alſo precipitated in the uſual way. On the pieces of alcyonium, from which the water had been decanted, ſome lixivium of potaſh in it's cauſtic ſtate was poured, and being boiled, the whole of the membranaceous or pulpy part was diſſolved, and a ſubſtance exactly ſimilar to Chaptal's animal ſoap was formed; while the calcareous part ſubſided to the bottom of the veſſel. *A. ficus*. This was unchanged in ſhape in the acid, and like a ſtrong, thick membranaceous ſubſtance of a fibrous texture. A little phoſphat of lime was precipitated by pure ammonia, from the acid liquor; after which, a copious precipitate of carbonat of lime was got by potaſh. *A. arboreum*. The calcareous part was ſoon diſſolved in nitric acid, but the form remained, and ſtill appeared like a pale yellow porous ſubſtance, enveloped by a ſkin or epidermis. Ammonia had no effect, but carbonat of lime was obtained by potaſh. Incinerated and diſſolved phoſphat of lime was obtained, with a large proportion of carbonat. As this phoſphat, therefore, appeared to have been defended by the membranaceous part from the acid, a complete ſolution of the alcyonium was made, and then, like that of the burned, it yielded phoſphat of lime, and the liquor became orange coloured as ſoon as the ammonia was added. A large portion of gelatin was procured, and animal ſoap formed; whilſt the calcareous part was ſeparated during the boiling, and fell down in the form of a fine powder. From this examination of the alcyonium, it appears, that as the ſponges reſemble the horny ſtems of gorgoniæ, ſo theſe ſpecies of alcyonium reſem-

ble in external, and chemical characters, the flefhy or cortical fubftance, which invefts fome of thofe bodies; and that they chiefly differ from the *gorgoniæ*, by being deftitute of the horny ftem, which, in the latter, feems to fupply the place of bone.

From the above experiments and obfervations, Hatchett thinks there is reafon to conclude, that the varieties of bone, fhell, coral, and the numerous tribe of zoophytes with which the laft are connected, only differ in compofition by the nature and quantity of the hardening or offifying principle, and by the ftate of the fubftance with which it is mixed or connected. For the gluten or jelly which cements the particles of carbonat, or phofphat of lime; and the membrane, cartilage, or horny fubftance, which ferves as a bafis, in and upon which the offifying matter is fecreted and depofited, feem to be only modifications of the fame fubftance, which progreffively graduates from a vifcid liquor or gluten, into that gelatinous fubftance fo often noticed, and which again, by increafed infpiffation, and by the various, or more or lefs perfect degrees of organic arrangement, forms the varieties of membrane, cartilage, and horn. The reafons which induce Hatchett to adopt this opinion originate from a feries of experiments, made with a view to inveftigate the nature and compofition of membrane, for which, fee *membrane*, *gelatin*, &c. Concluding remarks.

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EXTERNAL PARTS.

THE exterior coverings of animals, which appear to be produced for the purpofe of retaining their heat, and as a defence againft the inclemency of the weather, are *hair*, *wool*, *feathers*, and *filk*, which laft fubftance ferves to envelop the filk worm in it's cryftalline ftate.

The *hair* of different animals has been imperfectly analyfed by feveral chemifts. From it's horny and fixed nature, we are told by Achard, that he was unable to extract any thing from it, by boiling it in water, in open veffels; the hair he fubmitted to experiment was that of the horfe, the goat, the dog, the calf, human air, and the wool of the fheep. Hair and wool.

After boiling each fpecies of hair in Papin's digefter, he found, that in one hour, it was become fo foft as to give way when preffed between the fingers, and to be fomewhat ropy; that it had loft very little of it's weight, but had depofited in the water a gelatinous part, which gave it a yellow, or brown colour, and left by evaporation a glue; that the hair, except the human and wool, after being dried, had become brittle, and capable of being pulverized between the fingers, which, perhaps, arofe from the lofs of it's gelatinous part.

Hatchett obferved the fame, for when hair of various qualities, and taken from different animals, was long digefted, or boiled with diftilled water, it imparted to the water a fmall portion of gelatin, which was precipitated by the tanning principle, and by nitro-muriat of tin; and when the hair had been thus deprived of gelatin, and

was fubfequently dried in the air, the original flexibility and elafticity of it were found to be much diminifhed, fo that it eafily gave way, and was broken. And he is induced to believe from various experiments, that the hair which lofes it's curl in moift weather, and which is the fofteft and moft flexible, is that which moft readily yields gelatin; on the contrary, the hair which is very ftrong and elaftic is that which affords it with the greateft difficulty, and in the fmalleft proportion. Thefe remarks have been corroborated by the affertion of a confiderable hair merchant in London, who, during a long experience of upwards of forty years, has always found, that hair of the firft named quality cannot be boiled an equal time with thofe laft mentioned, without fuffering material injury in ftrength and flexibility.

By incineration, according to Achard, very little afhes were left behind; he found that one pound of each afforded the following quantity, viz:

	drachms.	grs.
Human	1,	20
goat's	$1\frac{1}{2}$,	$\frac{2}{3}$
pig's	$1\frac{1}{2}$,	22
fheep's ..	$1\frac{1}{2}$,	2
calf's	$2\frac{1}{2}$,	10
dog's	$2\frac{1}{2}$,	22
horfe's	3,	12

The colour of the afhes, in thefe experiments, was in general more or lefs yellow; whilft thofe from the hair of the horfe were reddifh. Thofe from the human, horfe's hair, and dog's, were taftelefs; and from the goat's and pig's, only as he thinks accidentally faline. The water in which thefe afhes had been lixiviated had no effect on the fyrup of violets, which appears to prove, they contained no fixed alkali.

Neumann and Bafter, on the contrary, found a fixed falt in thefe afhes.

By diftillation of thefe different fpecies of hair, Achard obtained, befides the carbonaceous refiduum, empyreumatic oil, and the ammoniacal fluid, afforded by all animal fubftances, with a cryftallized faline matter in the receiver, which was partly ftellated, and partly rhomboidal. This, on the addition of potafh, produced a very ftrongly penetrating fmell of ammonia, and a peculiar fort of animal ammonia; which he thinks, might, perhaps, arife from the acid of benzoin, as in urine. Expofed to diftillation.

Digefted with quick lime, during it's extinction, wool and human hair loft very little of their fixity, and nothing of their fupplenefs; on the contrary, that of the horfe, goat, and dog, as well as the briftles of the pig, after undergoing this operation, and becoming dry, were very fhort and brittle. Quick lime.

Mild alkalis have no effect upon hair, either in the cold, or at a boiling heat; but by digefting them twelve hours with cauftic alkali, they were converted into a jelly. Alkalis.

According to Chaptal, if a cauftic lye of potafh be faturated with wool or hair, a foap is formed, which he calls the foap of wool.

Hair, put into the vitriolic acid for twelve hours, in which time it was coloured brown, had not loft any of it's flexibility, but was fofter; and the human hair, after it was wafhed and dried, appeared partly white. On digeftion in this acid with heat, the hair was perfectly diffolved, and produced a ftrong fmell of fulphureous fpirit. The folutions were not affected by dilution with water. Vitriolic acid.

According to Berthollet, ſcourçd wool put into ſulphuric acid was diſſolved by a ſlight heat; at firſt the ſolution was colourleſs, but on increaſing the heat, it ſoon became blackiſh. Diſtilled with ſulphuric acid, under a pneumatic apparatus, there came over a large quantity of gas, five ſixths of which were carbonic acid. This acid having been abſorbed, the reſiduum was hydrogen gas. At the end of the diſtillation, a conſiderable quantity of very white ſulphat of ammonia was ſublimed; there remained a coal in the retort.

Nitrous acid. According to Achard, fuming nitrous acid, the fumes of which immediately changed dark and black hair to a reddiſh, and afterward to a white colour, without affecting it's ſolidity, corroded, and ſoon diſſolved both hair, wool, and briſtles. From this ſolution, pure water precipitated a yellowiſh flocky matter, half of which was ſoluble in alcohol, to which it gave it's yellow colour; and on the addition of water, became milky and turbid; which, however, became clear again after the depoſit of a flocky matter, greatly reſembling coagulated oil. This precipitate, on being diſtilled, afforded an alkaline water, a large quantity of empyreumatic oil, and a coal which left brick coloured aſhes. From the nitrous ſolution of the human hair, when evaporated to one half, aroſe ſome ſmall needle-like cryſtals. Weak nitrous acid had no effect on hair in the cold, but entirely diſſolved it at a boiling heat, became yellow, and had a ſweetiſh ſmell, the ſame as when boiled with fat oils, and other animal matters. Water, it appears, had no effect on this ſolution, which is ſomewhat extraordinary, ſince Berthollet having treated hair and wool with eight times the quantity of common nitrous acid in cloſe veſſels, obtained ſolutions, which, on becoming cool, depoſited a fat matter; and on cryſtallization, a large quantity of

oxalic acid. This experiment of Berthollet lets great light on thofe of Achard. From fix drachms of wool, he obtained three drachms and four grains of the oxalic acid; hair alfo gave it a deal of fat, but not fo much oxalic acid as wool.

Achard found alfo, that the muriatic acid foftened hair in the cold, and entirely diffolved it at a boiling heat. The dark brown, or nearly black folutions it forms, afford no depofit on the addition of water. Muriatic acid.

Berthollet found, that the muriatic acid diffolved wool more readily than the fulphuric, but a more continued heat was neceffary before the folution became black. Simply diftilled with a receiver to the retort, a confiderable portion of muriat of ammonia came over toward the end, one part of which was brown, whilft that more advanced into the neck of the retort was white. There remained a much more confiderable quantity of charcoal than with fulphuric acid; the lixiviated coal gave a folution, which contained an evident quantity of iron. To judge of the vapours by the odour, which efcaped toward the end of the operation, hydrogen gas was difengaged. It may be remarked, that with the fulphuric acid, very little coal remains, but much carbonic acid is obtained; whilft with the muriatic acid, as a much greater quantity of carbon is left, we may conclude, that very little carbonic acid ought to be difengaged.

According to the experiments of Van Mons, it appears, that the oxygenated muriatic acid gas converted quills, wool, calf's hair, and filk, after having been kept fome days in it's atmofphere, into gelatin; the two firft fubftances acquired a red colour. Oxygenated muriatic acid.

Alcohol, vitriolic ether, the fat and ethereal oils have action upon hair either in the cold or with heat. Alcohol.

According to Thompfon, hair, as well as wool and Light.

ſilk, when expoſed under water to the rays of the ſun, emit dephlogiſticated air.

Fermentation.

From the dry and horny nature of theſe ſubſtances, they are prevented from undergoing the putrid fermentation; but we have an account given us by Carette, of the ſpontaneous combuſtion of wool. According to this author, wool and animal ſtuffs are liable to this change, when they are laid in heaps, accompanied with a certain degree of humidity. He gives an inſtance of an old woollen ball, which having been oiled in order to render it more elaſtic, and covered, ſome time after nothing but a black powder was found in the cover, which perfectly reſembled a carbon: he alſo relates, that a manufacturer of Liſle, having put a piece of cloth into his warehouſe which had not been cleanſed, it took fire in a few days after, and that ſeveral inſtances of the kind had occurred.

Spontaneous combuſtion.

This has been obſerved by Sonnini: he ſays, in the ſhipping of wool it is of importance to know, that great care ſhould be taken to prevent it's imbibing any moiſture, for in ſuch caſe, it heats, inflames, and is in danger of ſetting fire to the veſſel.

Component parts.

From theſe experiments it appears, that hair in a chemical view reſembles the fibrous parts, whilſt water only extracts a little of the gelatin. Wool inclines to a fatty nature, as the lye of cauſtic alkalis perfectly diſſolves it on boiling, and forms a ſoap with it as well as with hair.

It now remains to give a ſhort deſcription of the uſes of theſe ſubſtances in the arts, as far as they can be conſidered chemically.

The arts.

It is well known that the art of the hatter conſiſts in forming with hair, wool, and fur of different animals, a kind of ſtuff of a denſe, compact texture, capable of aſſuming and preſerving any figure that may be given it,

To obtain this object, a variety of proceffes are employed, partly chemical, and partly mechanical, which may be reduced to four principal operations, viz. felting, fulling, dyeing, and preparation.

FELTING.

If any fpecies of hair or wool be infpected by the microfcope, it appears fmooth and polifhed, yet if rubbed between the fingers, held by the point, and drawn to the root, the refiftance is more confiderable than in the contrary direction; the motion is likewife tremulous, and there is a chirping noife. Likewife, if a hair be held between the finger and thumb, and rubbed by alternately moving them in the direction of it's length, a progreffive motion will be produced, which is always with the root end foremoft. The fame ftructure may be fhown by tying two hairs together, and then giving the knot a few blows between the palms of the hands, for the knot will either untie itfelf or draw clofer, according as the afperities of the furfaces are placed in tying. From this mechanifm which is common to wool, and every other kind of hair, which, according to Monge, have their furface compofed either of fcales like thofe of fifh or imbricated cones, like the horns of animals, may be deduced the harfh feel of woollens againft the fkin, compared with linens, and their irritating effect upon wounds. It is this difpofition to progreffive motion end ways, which caufes hair to entangle and *felt* itfelf when preffed by the hatter between two pieces of linen, to which they do not unite from it's fibres being fmooth. Cut hair is better than fuch as is plucked, becaufe the bulbous roots prevent the progreffive motion. The fibres of wool being

crooked, muſt naturally move in curves; but thoſe of the hare, rabbit, and beaver, being ſtraight, cannot be uſed alone in felting, until after a previous operation, which conſiſts in rubbing them with a nitrous ſolution of mercury, by means of a bruſh, before they are ſeparated from the ſkin. The ſolution acting only on one ſide of the hairs, renders them crooked. The ſtraight hairs are uſed for felting hats, in which operation the action muſt be continued for a determinate time only, otherwiſe they would paſs through and come out on the oppoſite ſide. The diſpoſition of wool to felt itſelf, is an impediment to the carding and ſpinning proceſſes; hence oil is uſed, which diminiſhes the power of the hairs to act on each other; but at the fulling mill, ſoap and marle are uſed, which carry off the oil and reſtore the wool to it's former ſtate, in conſequence of which, the fulling proceſs takes place, and the cloths are rendered narrower, ſhorter, cloſer, ſtronger, and thicker. The balls of hair in the ſtomach of certain animals which lick each other, are felted by the action of the ſtomach. To which may be added, that a ſimilar cauſe is the chief reaſon why beds of cock and hen feathers are inferior to thoſe of gooſe feathers; the latter being much ſtraighter, do not form the hard flat balls which abound in the former. This work, which is entirely mechanical, forms the *felt*, which is a kind of ſoft ſpungy ſtuff, of greater or leſs thickneſs, and in it's firſt ſtate, of a looſe and imperfect texture. It's fibres would ſoon diſunite from their weak connection; hence to give it requiſite denſity and conſiſtence, it undergoes the operation of *fulling*.

Fulling. This, which is in a certain reſpect the completion of felting, has for it's object the intimate connection of the fibres, and a more perfect and durable coheſion of the whole maſs. For this purpoſe, the mere mechanical act of preſſure is inſufficient; the reſult would be a formleſs

maſs without conſiſtence. For the fulling, it is neceſſary to make uſe of a bath of water heated nearly to ebullition, into which are put, in France, ten or fifteen pounds of lees of wine, for every hundred pounds of water. The heat is kept up the whole time of working, and every three or four hours, a new quantity of lees is added. Into this bath the workmen plunge their *felt*, and begin their ſecond proceſs. The felt is dipped in, and immediately taken out again and ſqueezed, bent and rolled, by preſſure, in different directions, ſometimes with the hand defended by leather, and ſometimes by a roller, or other ſimilar inſtrument. This is repeated until the ſtuff is well condenſed, and has acquired the requiſite ſolidity; hence the lees added muſt be conſidered as a chemical ſolvent, acting directly on the ſubſtance of the hair, and producing, either by ſoftening or ſwelling it, an alteration neceſſary to inſure the coheſion of the different fibres of the ſtuff.

The editor of the French Encyclop. Méthod. affirms, that it is the alkali or potaſh of the lees, which determines the fulling. Chauſſier has, however, found the aſſertion of the editor to be erroneous; to prove which, nothing more is neceſſary than to dip a piece of blue paper in the bath, which inſtantly becomes red, and if after ſeveral hours work the ſtate of the bath be examined again, it is found that the acting part, which is the acidulous tartrite of potaſh, is partly exhauſted, and the workmen ſoon perceive the want of a new portion; and if we conſider the ſparing ſolubility of the acidulous tartrite in cold water, it will appear why the water muſt be kept nearly boiling. Hence it is evident, that it muſt act by the portion of acidule it contains. It was this firſt obſervation that induced Chauſſier to ſubſtitute the ſulphuric acid inſtead of the lees, which although unknown to this chemiſt, had been uſed as a great ſecret in foreign ma-

nufactures. He found twelve drachms of this acid sufficient for one hundred pounds of water, and that this method was much preferable to that of wine lees, as being not only more convenient and economical, but the health of the workmen was not impaired by the excess and duration of the heat, the thick vapours, and the disgusting odour which exhales from the bath, particularly when the lees had been putrid and mouldy. A boiling heat is not necessary as formerly; ninety, or one hundred degrees of Fahrenheit being sufficient for good *fulling*. It also saves fuel; cauldrons of lead may be substituted for those of copper, and the felt prepared is of superior quality.

With respect to this process, it is only necessary to mention, that hats felted in the new manner take the dye better than in the old way, and that oak bark is substituted to nut-gall with advantage.

Preparation. This process, called *preparation*, consists in lining the inner surface of the crown, as well as of the brim of the hat, with a glutinous substance, which, by drying, gives firmness to the work and preserves it's form. This chemist found a solution of glue in a decoction loaded with the mucilage of linseed oil the best, whilst Margueron recommends the mucilage extracted from the leaves of the horse chesnut when it's foliage is in full vigour. A strong decoction of these leaves, which contains a great portion of mucous and adhesive matter, is used with the glue. These are better than gum arabic and other friable gums which become brittle.

· Neumann's Chemical Works by Lewis, 2d. edit. vol. 2.—Withof, Anatom. Pili hum. Gotting. tom. 2.—Achard's Chem. Unterfuchung ueber die Beftandtheile der Haare von verfchied. Thier. in his Chem. and Phyf. Abhandlungen. 1. p. 166.—Berthollet, fur la Nature des

Subſtances animales, Mém. de l'Acad. Royal des Sciences. 1784. Paris.—Leonhardi's Macquer's Wœrterbuch, vol. 7. article *Haare.*—Monge Annal. de Chim. vol. 6.—Chauffier Obſervation ſur le Mecaniſme du Feutrage, Journ. Polytec. cap. 1, p. 160.

FEATHERS.

Feathers. THESE, according to Hildebrandt, as well as other chemifts, are fimilar to hair. Hatchett found, that feathers, when digefted in boiling diftilled water during ten or twelve days, did not afford any trace of gelatin by the teft of the tanning principle, but nitro-muriat of tin produced a faint white cloud. The fame was obferved when quill was thus examined.

SILK.

Silk. THIS is the production of the larva or caterpillar of a phalena, of which feveral fpecies afford it; the phalena atlas of Linnæus gives the greateft quantity, but that from the phalena bombyx of Linnæus is the moft generally made ufe of in Europe. The matter from which it is fpun is found enclofed in two purfes or fmall inteftines of the animal, and this being taken out and extended, forms the Indian weed fo well known to fifhermen.

The native place of this infect is China; whence it was carried to Hindoftan and Perfia. Silk was not known in Greece or Rome till the reign of Auguftus, and we are informed, that during feveral ages it was fold for it's weight in gold. In 555, filkworms were tranfported from India to Conftantinople, by two monks, and manufactures were made at Athens, Corinth, and Thebes, whence it was brought into Europe, in 1130, by Roger, king of Sicily, on his return from the Crufade to the Holy Land; he eftablifhed manufactures

at Palermo, and in Calabria; afterward it ſpread over Italy and Spain, and in the reign of James the Firſt was conveyed to England.

According to Reaumur, this is not the only animal that affords this ſort of matter; he found ſeveral ſpecies of ſpiders which encloſed their eggs in a very fine ſilk, and afforded a much finer and ſtronger thread than that of the common ſpecies; it was alſo of various colours, ſuch as white, yellow, ſky blue, gray, and coffee-coloured, but this has as yet undergone no chemical inveſtigation.

Silk is of different ſhades of colour; from a white, it goes through all the ſhades of yellow, even to a reddiſh colour. It is of a ſtiff texture, and ſhines from the gum varniſh that covers it.

Expoſed to the action of water.

It is not acted upon by water at a boiling heat (it's gum is only affected); from what, however, Chappe has ſaid upon the ſubject, ſilk, before it is ſpun, and juſt taken from the caterpillar, may be ſo diluted with water as to form a ſort of gluten, which may be blown into bubbles offering all the colours of the rainbow, and far ſuperior to thoſe balloons made of ſoap and water, which ſoon vaniſh. On the contrary, we are informed that thoſe made of this ſilky matter are of a permanent texture, perfectly tranſparent, preventing even the moſt light gas from penetrating through it. He has formed ſmall balloons of it, the diameter of which did not exceed three inches, which he filled with hydrogen gas, and kept ſuſpended in an apartment, nor had many of them ſuffered any thing after twenty-four hours. To form this gluten, great care is required; it cannot have all it's ſuppleneſs and ductility until it has arrived at it's greateſt maturity, which is when the worm is diſpoſed to form it's ſilk. That the yellowneſs of which is too marked, a diſeaſed ſtate very common to theſe inſects, will not do. After

Experiments of Chappe.

being cut from the worm, it muſt be put into a glaſs, unbruiſed, and when a ſufficient quantity is procured, it muſt be well waſhed and cleaned with great precaution; the water decanted and freſh applied. By the effect of the ſolution of the colouring parts of the ſilk, as well as of the excrementitious parts of the inſect, this chemiſt informs us, this pure and tranſparent water becomes turbid, yellowiſh, and obſcure, and in an hour, of a green, tending to a black. In this ſtate it muſt be decanted and freſh water added, and repeated until the yellow is extremely weakened, and the obſcure green diſſipated. The thermometer of Reaum. being at 12 or 15° above zero, two hours and a half are ſufficient to diſſolve the colouring parts and excrements, of which it muſt be purged to poſſeſs all it's ductility. The matter thus prepared is to be put into a glaſs mortar, a little diſtilled water added, and the mixture to be accelerated by trituration; a little more water is then added as the liquor thickens, whilſt one part of water to three of the ſilky matter, commonly gives it all the ſuppleneſs and ductility neceſſary. In about half an hour after, it's weak yellow colour becomes of a greeniſh tinge, which is the time of it's being ready.

Chappe took tubes of glaſs, of a line or more at the orifice, and ſomewhat excavated at the inferior part, which he uſed in the ſame manner as in making balloons of ſoap and water; it muſt be ſo blown as to be made at ſeveral times, for a rapid and ſudden diſtention always deſtroys it. When it has acquired it's utmoſt extenſion, which, in general, does not exceed three inches, the water is let evaporate without detaching the bubble from the tube; it is then dried in the ſun. To take away the internal drops of water, Chappe uſed a ſmall capillary conical glaſs tube, by which he attracted them. The colours ariſe in proportion as the water evaporates, and preſent

themſelves in the ſame order as thoſe of the rainbow. Expoſed to the air, it becomes tarniſhed and opake, but by means of a glaſs and vapour, may be preſerved for ſeveral years. It has been uſed in medallions, and as ornaments for buttons.

Berthollet found, that the nitrous acid perfectly diſſolved ſilk. By means of ſeven or eight parts of the firſt, to one of the other, he obtained ſome oxalic acid, but not ſo much as from wool; and a fatty matter was depoſited. Nitr us acid.

Welter, having treated ſome ſilk with the nitric acid in order to extract ſome oxalic acid, he was ſurpriſed at the end of the operation not to find any, but inſtead of it, he found an unknown ſalt, ſilky, of a gold colour, and which, on the approach of a red hot coal, took fire like gunpowder. Nitrous acid.

The manner in which he made the experiment was this. On one part of ſilk, he poured ſix parts of common impure nitric acid, to which he added a little concentrated nitric acid. The mixture was left to repoſe two days, and then diſtilled. He then returned what had come over into the retort again, and put it on a filter. As he thought the oxalic acid cryſtallized too quickly, he poured it back into the retort again, and added to it ſome water which had ſerved to waſh the filter. He then extracted a part of the water, and endeavoured to cryſtallize the reſiduum, which did not take place; he then added what was in the receiver to that in the retort, and diſtilled it again. At laſt, having performed the ſame circle of operations for ſeveral times, the reſiduum was an acid liquor, containing ſome ſmall granular cryſtals, (which were not examined) and it was reduced to about one half of the ſilk employed.

This liquor ſubmitted to different proofs ſhowed no trace of oxalic acid; it was yellow, tinged the fingers of that co-

lour, and communicated to white ſilk a beautiful yellow, which was not weakened by waſhing it with water. To ſaturate this liquor he mixed ſome chalk with it, and finiſhed the ſaturation by lime; having afterward extracted it, he poured ſome alcohol upon it, and there ſeparated a gummy matter to all appearance, which was ſet apart. The alcohol was diluted with water and evaporated. There remained a yellow ſubſtance with the ſolutions of muriat and nitrat of lime. Having decompoſed theſe ſalts by the carbonat of potaſh, and ſeparated the carbonat of lime, the decanted liquor was left on a ſand bath. The day after, the glaſs was found lined with gold coloured cryſtals equal to ſilk in fineneſs, which detonated like gunpowder; the ſmoke reſembled that from burnt reſin.

It's properties. This yellow ſalt is ſoluble in water and alcohol. It cryſtallized on cooling. Oxygenated muriatic acid poured upon it's ſolution, deprives it of it's yellow colour, and renders it milky.

The ſulphuric acid diſengages the odour of nitrous acid from it's cryſtals. The muriatic acid precipitates from it's ſolution ſome ſmall, whitiſh, micaceous cryſtals, which in the fire are volatilized into a ſmoke bitter to the palate. This ſmoke is inflammable, and burns like eſſential oils.

He treated ſome freſh ſilk by the nitric acid, and, after having obtained at different times cryſtals of oxalic acid, he poured ſome weak nitric acid on the reſiduum, which was of the conſiſtence of honey. After having warmed the mixture to diſſolve all of it, it was left to repoſe two days, when he again found ſome cryſtals of oxalic acid, and ſome granulated, yellowiſh cryſtals, extremely bitter and without any acidity, tingeing the ſaliva and the tongue of a yellow colour, volatile in the fire, and indeſtructible by the concentrated nitric acid, which only took away their colour, and this on dilution with water reappeared.

Having ſaturated a little nitric acid, mixed with this ſubſtance, with potaſh, it was evaporated, and the reſiduum took fire like the ſilky ſalt before mentioned. Welter looks upon this laſt to be a triple ſalt, compoſed of nitre of potaſh combined with the yellow ſubſtance to which he has given the name *Bitter*.

The cryſtals of yellow *bitter*, examined by the magnifier, appeared to be octoedrical, having two oppoſite ſummits truncated, whence reſult ſquare rectangular tablets, the edges of which are cut ſloping towards the two ſurfaces. called, *Bitter*,

Since animal ſubſtances become yellow by the contact of the nitric acid, Welter endeavoured to extract *bitter* from the fleſh of the ox; but he found it combined with another ſubſtance, which was as unalterable as itſelf by the nitric acid. This combination, ſoluble in concentrated nitric acid, is ſeparated from it by water, in the form of a yellow powder, which does not loſe it's colour in the air, and which may perhaps be of uſe in the art of painting.

What gave Welter reaſon to preſume that the yellow powder was compoſed of *bitter* and of another new ſubſtance was, that, on treating ſpunge by the nitric acid, he obtained ſome of this laſt ſubſtance, without colour, ſoluble in concentrated nitric acid like the preceding powder, and, like it, capable of being precipitated by water; knowing, beſides, how greedy *bitter* is of combination, eſpecially with animal matters, and how ſolid it's tinctures are:

Welter thinks that bile, perhaps, owes it's colour and bitterneſs to this ſubſtance, which he calls *bitter*.

The vitriolic as well as the muriatic acids, when concentrated, diſſolve ſilk. Muriatic acid.

According to Weſtrumb, ſilk and wool, when treated with the dephlogiſticated muriatic acid gas, or when di- Dephlog. mur. a.

luted with water, inſtead of being bleached like cotton and linens, always became of a yellow colour, and loſt a part of their ſolidity.

Alkalis. The cauſtic alkalis corrode and diſſolve it.

Fire. Silk, on being expoſed to heat, gives by diſtillation the ſame as other animal ſubſtances. According to Neumann, few ſubſtances afforded him ſo much volatile alcali; and Tournefort ſays, that it contains more than hartſhorn; from 15 ounces of ſilk he obtained 2 drachms of volatile ſalt.

Hence it appears, that ſilk, like coal, reſembles the fibrous matter, although it has been looked upon as concrete albumen. Fourcroy looks upon it as a kind of vegetable mucilage or gummy matter, with a peculiar animal oil, which gives it flexibility, ductility, and elaſticity. It, however, differs from vegetable ſubſtances; firſt, by the volatile alkali it affords by diſtillation; ſecondly, by the carbonic acid gas obtained from it by the nitrous acid; and thirdly, by the peculiar oil which this acid ſeparates, in proportion as it converts it into ſaccharine acid. According to Gren, it is an animal-vegetable matter, the vegetable part proceeding from the food of the worm. It is convertible into paper. Gadolin found that crude ſilk expoſed to the ſun, after being moiſtened, afforded a great deal of dephlogiſticated air.

Light.

Varniſh of ſilk. Silk is divided into two kinds, viz. *unwrought* or *crude*, and *wrought*. In it's natural ſtate it is diſtinguiſhed by the firſt name, being covered with a varniſh, which by ſome has been looked upon as a gum, by others as a reſin, to which it owes it's ſtiffneſs, brilliancy, and elaſticity. Bergman, on the contrary, affirmed, that this varniſh was neither gum nor reſin, but of an oily nature. Deprived of this it is called *wrought ſilk*. It likewiſe contains a yellow colouring part.

This varniſh is ſoluble in boiling water, and conſti-

tutes ſomewhat more than one quarter of the weight of the ſilk.

According to Berthollet, when ſeparated it is black, brittle, and of a ſhining fracture.

It is eaſily ſoluble in hot water, and Berthollet found, that it left very little reſiduum on the filter; the ſolution, which was clear and of a greeniſh yellow colour, was not ſenſibly affected, either by acids or by alkalis. A ſolution of alum produced a precipitate of a dirty white, that of ſulphat of copper of a dark brown, and that of ſulphat of iron of a brown colour. A ſolution of muriat of tin gave a white precipitate, and acetite of lead a brown one. All theſe precipitates were in ſmall quantity, and more or leſs viſcous. An infuſion of galls or of ſumach produces a white precipitate. Alcohol does not diſſolve this ſubſtance even by ebullition; it, however, takes up it's yellow colouring part. Hot water. Alcohol.

On diſtillation, Beaume and Berthollet obtained the ſame products as from animal ſubſtances. Hence this varniſh is of an animal nature, which is the reaſon that ſoapſuds, which have been made uſe of to deprive the ſilk of it, eaſily become putrid. When it is no longer retained by the affinity it has for the ſilk, it is eaſily, as has been ſeen, ſoluble in water, but not in alcohol. Berthollet is of opinion, that, although this ſubſtance is not of a vegetable nature, the name of gum is well adapted to it. Diſtillation.

The yellow colouring part which ſilk poſſeſſes beſides it's gum, and which has been juſt obſerved to be ſoluble in alcohol, being ſeparated by this means, the gum is brown, which ariſes from the heat it ſuffers from ebullition; for if this colouring part be taken off by the proceſs of Beaume, which will be deſcribed, the ſilk remains white. This alcoholic ſolution of colouring matter left, on evaporation, a ſcaly reſiduum of an amber yellow colour. It's colouring part ſoluble in alcohol.

Berthollet mixed a few drops of muriatic acid with nearly two ounces of alcohol, which he boiled on 20 grains of ſilk gum, when a ſolution took place; but, on cooling, it took the form of a jelly.

Bleaching. For the greater part of uſes in the arts to which ſilk is deſtined, it is neceſſary that it ſhould be deprived both of it's gum and colouring part. This double object, according to Berthollet, is effected by means of ſoap; and to make the operation more or leſs perfect depends on the proportion of the ſoap, although it appears to change the luſtre of the ſilk. Thus, for inſtance, to make it fit to receive ordinary colours, a ſolution of 20lbs. of ſoap to 100lbs of ſilk is ſufficient, taking care to have a ſufficient quantity of water, and the boiling to continue three or four hours. For ſilk that is to be died blue, the quantity of ſoap is augmented, and a larger quantity is employed for ſcarlet, cherry colours, &c., ſince it is neceſſary for theſe colours, that the ground of the ſilk ſhould be whiter than for leſs delicate colours. If the ſilk is to be uſed white, it undergoes three operations with ſoap, and in the laſt it is called the *bleaching*, by which a light ſhade is given it under different names, as China white, ſilver white, azure white, thread white, &c.

For the China white a ſlight reddiſh tinge is communicated to it by an American ſeed (bixa orellata, Lin.) called anotta. For the azure, a little refined indigo is uſed. After this it is neceſſary to expoſe it to the vapour of ſulphur, if intended for white ſtuffs, ſince the whiteneſs from the preceding proceſſes is not ſufficiently ſplendid.

The Abbe Columb found that ſilk, ſcoured by the action of water alone at a boiling heat, became much better for dyeing, and was more ſtrong than that ſcoured by ſoap. A ſtrong ebullition of eight hours, however, is neceſſary to diſſolve all the varniſh of the ſilk, but it preſerves it's yellow colour.

For a far ſuperiour proceſs we are indebted to Beaume, who arrived at depriving yellow ſilk of it's colouring part, without attacking it's gum, and, conſequently, without depriving it of it's elaſticity and brilliancy. Before the labours of this chemiſt, the art of bleaching ſilk was unknown in Europe; and he informs us, it coſt him ſix years of great diligence and induſtry to create and bring it to perfection. The only author who had written on this ſubject was Poivre, who believed, that in China the ſilk was bleached by expoſure to the ſun, and he looked upon this luminary as the only bleacher of ſilk.

The Nankin ſilk is perfectly white, ſilvery, brilliant, and, not being deprived of it's gum, has all the ſtiffneſs natural to unboiled ſilk; and the great deſideratum was to give that of Europe the ſame whiteneſs, without depriving it of the other properties. It was believed, that the Nankin ſilk was natural; and the late Soudaine obtained ſome eggs from China, from which he got ſilk both of a yellow colour and ſome as white as the Nankin. It appears, however, that almoſt all from that country is bleached by a proceſs, which Beaume informs us he has diſcovered.

His firſt object was the deſtruction of the cryſalis, which pierces the ſilky cod in ten or twelve days. This had been effected by a furnace, heated to 70°. But the inconveniences were, that the heat ſpoils a part of the ſilk on the ſurface of each cod, hardens it, and makes it difficult to ſoften in warm water at the time of winding. One pound of ſpun ſilk is commonly procured from 8lbs. of the cods, whilſt 18 ounces of the ſame, but more beautiful and brilliant, are procured from the ſame quantity of green cods, or thoſe which had not been expoſed to the furnace, and the winding is performed by a leſs heat and with more eaſe. Hence the uſe of a method of winding the ſilk, when green, without the inconveniences of the

Extinction of the cods.

fire; in which Beaume fucceeded by means of alcohol, with this advantage, that this method fhows the cods, in which the cryfalis was previoufly dead, and which muft be feparated from the others, fince the infect foon becoming putrid, furnifhes a liquor, which gives the filk a deep brown colour; and thefe are diftinguifhed by having brown or black fpots on their furface.

1ft Infufion. Previous to the bleaching, the wound filk muft be infufed in water at about 45° for two hours, to deprive it of a little of it's gummy part. During this infufion, it foftens, and the water is rendered flightly amber-coloured; the filk is then dried, and being thus prepared, 6lbs. of it are put into a well wafhed ftone pot, to which are added 48lbs of alcohol mixed with 12 ounces of very pure muriatic acid; the pot is then covered, left until the next day, or until the liquor from it's beautiful green paffes to the colour of dead leaf; the liquor is then let run out by a hole in the bottom, and alcohol is poured upon the filk at feveral times, and let run off, until it runs off clear.

2d Infufion. The filk now undergoes a fecond infufion of the fame kind as the firft; it is then left covered twenty-four hours, or fometimes two, three, and even fix days, until the filk becomes perfectly white, and is afterwards wafhed by pouring alcohol upon it until it runs off clear.

3d Infufion. It is now fubmitted to a third infufion of alcohol alone, 48lbs. of which are poured upon it; it is let ftand until the next day, and the alcohol is then laid afide to wafh the filk of the firft infufion. When nothing more runs from it, it ftill retains it's weight of alcohol, which is to be wafhed away by clear river water, until nothing but water runs off. The marine acid likewife, with which it is impregnated, is to be wafhed off by the fame means; but the water muft contain no nitre, as this tarnifhes it. The filk is placed under the pump, and coarfe cloth put

over it for a filter, the water is then made to paſs through the ſilk, until it no longer reddens the tincture of litmus; the pot is then ſtopped and filled with water, which is changed once or twice every twenty-four hours, after which the ſilk is completely bleached and waſhed. If the muriatic acid be not completely waſhed off, the ſilk is rough to the touch, and in time it's threads become brittle. If it be wrapped in woollen, and placed in the current of a river, it is completely waſhed in five or ſix hours.

It appears that, although the mineral acids are of all ſaline ſubſtances the moſt active and deſtructive, they may, however, be applied to ſilk by the intermedium of alcohol without detriment. Beaume has even uſed two ounces of muriatic acid to 1lb. of alcohol without any hurt to the ſilk, and this acid is preferable to the two others, provided it be free from the nitrous acid, as this laſt has the inconvenience of reddening the ſilk; but alcohol mixed with muriatic acid extracts from yellow ſilk a colour, which immediately paſſes to a beautiful green tending to a blue. This on three or four hours expoſure to the ſun becomes of the colour of dead leaf, whilſt pure alcohol alone extracts a beautiful lemon colour from the yellow ſilk, which is not affected by the ſun, and is not depoſited for ſeveral years, although the ſame ſilk, encloſed in a bottle and expoſed, loſes it's colour in a ſhort time. Remarks.

Alcohol alone poſſeſſing the property of taking away the yellow colour of the ſilk, it was the intention of Beaume to have employed it; but, although it has the advantage of converting theſe yellow ſilks into a ſtate of natural whiteneſs, and they are afterwards made perfectly white by one infuſion only of the alcohol and the acid, yet it is not ſufficient to bleach them entirely,

and it has likewise inconveniences which the other has not.

To this may be added, that, in order for the first infusion to have been well made, the silk must have lost all it's yellow colour, and the liquor have changed it's colour a little; that it's duration depends on it's temperature; at 20°, it is often made in ten or twelve hours; if exposed to the baln. maræ in two or three hours, and all the infusions may be made in one day. After this first infusion, the silk appears of a greenish colour, which goes off on washing.

By these means the yellow silks of Europe may be obtained as beautiful, and even more so, than those of Nankin, and by bleaching the white silk, which is natural, it is infinitely more beautiful.

ATTRACTION OF THE EXTERNAL PARTS FOR COLOURING MATTER.

Attraction of the external parts for colouring matter.

SINCE the exteriour parts of animals are converted into artificial clothing, and are subject to have their natural colours changed for a variety of others by the art of dyeing, it will be necessary, before the conclusion of this article, to take some notice of the chemical attraction they have for colouring matter.

It appears that, from the different composition of animal substances when compared with vegetable, the azote and hydrogen of the first being disposed to take an elastic state, their component particles have less adherence to each other than those of the second; hence hair, wool, and silk have a stronger attraction for colouring matters than cotton, linen, or hemp. With respect to wool, the laminæ or zones, which form the roughness of it's fibres,

are well fitted to contain the particles of colouring matters; but their interftices being fmall, no colour, according to Bancroft, can be conveyed into the cavities, until dilated by hot or boiling water, which is not the cafe with filk. This dilation and contraction of the interftices, with the fuperiour chemical attraction, which animal fibres have for colouring matters, explain why many colours, dyed upon wool and hair, proved fo much more durable than on cotton and linen, and the finer and whiter the wool, the fooner and more penetrated it is with the matter, whilft the coarfe wool receives colours with difficulty; likewife from it's ftrong attraction, wool is died fcarlet in a bath, which has no effect on cotton. With refpect to filk, from it's lefs difpofition to receive and retain colours, or to combine with colouring matter, it bears fome refemblance to vegetable fubftances, or rather feems to partake of a middle nature between the animal and vegetable, which may arife from it's fibres having neither a fimilar organization, by which it is capable, like wool, of having it's pores opened by hot water, of which it has no occafion, like the vegetable, or, more probably, as Berthollet is of opinion, from it's containing lefs azote and hydrogen; colours however dyed on filk are more lafting than when dyed on linens and cottons, which is the refult of it's greater affinity with the colouring matter.

Another circumftance refpecting thefe fubftances is, that from their difference of compofition they are more likely to be deftroyed by mordants*, by their greater affinity for them than vegetables have; hence, fixed alkalis, pure or cauftic, deftroy them by their combination to faturation, and by this means lofe their caufticity. Hence it follows, that wool, hair, and filk are not able to fuftain the lyes, and the employment of alkalis can only be made Mordants in dyeing.

* N. B. Mordants are thofe fubftances that ferve as a medium of union between the colouring matter and the fubftance to be dyed.

with great precaution in the proceſſes of dyeing them, which is unneceſſary with reſpect to cotton, linen, &c. Wool, as it is naturally clothed with a fatty ſubſtance, undergoes the act of ſcouring previous to taking the dye. This is generally done by hot water and putrid urine, which, when the wool no longer is milky, is ſufficiently cleanſed. In this proceſs the ammonia combines with the fatty ſubſtance, and forms a ſoap, which renders it ſoluble in water. For the generality of colours it is prepared by being boiled with ſaline ſubſtances, as alum, and tartar, called the *boiling*. Silk, from the ſame reaſon, as it has leſs affinity with colouring matter than wool, affords a greater reſiſtance to the action of mordants; but although their action is weaker than on wool, it is neceſſary to make uſe of them with great precaution, ſince the brightneſs of colour, required in ſilk, appears to depend on the ſmoothneſs of it's ſurface.

The mordant for ſilk is alum; without this, the greater part of the colours applied to it would have neither beauty nor durability; when, therefore, the ſilk has been ſoap-waſhed, it is put into a cold alum bath for about eight hours, and then waſhed; a hot bath would impair the luſtre of the ſilk.

It therefore appears that alumine is the grand mordant for animal ſubſtances, and the affinity which it has for them has been proved by Berthollet by direct experiment. He formed this combination by mixing an alkali ſaturated by an animal ſubſtance, with a ſolution of alum. A double exchange was the conſequence. The alkali united with the acid of the alum, whilſt the alumine combined with the animal ſubſtance was precipitated. He likewiſe proved it by another experiment. Having mixed a ſolution of glue with a ſolution of alum, he precipitated the alumine by an alkali, which was found to have dragged the glue along with it, and to have united

with it. It had the appearance of a femitranfparent jelly, and dried with difficulty. The reafon of tartar being added to the alum, with refpect to the wool, is, that as it is much more tender than filk, it moderates the too lively action of the alum upon it. All metallic oxyds, likewife, ferve as mordants to animal fubftances, and even fome animal fubftances themfelves.

Neumann's Chemiftry by Lewis, vol. 2.—Fourcroy's Elements.—Découverte d'un Tiffu tranfparent de la Matière foyeufe du Ver à Soie, par M. Chappe. An. de Ch. tom. 2. p. 113.—Notice fur quelques Matières particulières, trouvées dans les Subftances animales, traitées par l'Acide nitrique, par le Cit. Welter, ibid. No. 87. p. 301.—Sur le Combuftion de différens Corps dans l'Acide muriatique dephlogift. par M. Westrumb. ibid. tom. 6. p. 240.—Obfervations fur la Diffolution du Vernis de la Soie, par M. Coulomb. Journ. de Phyf. Juill. 1785. p. 95.—Berthollet, Elémens de l'Art de la Teinture. 2 vol. Paris. — Bancroft on Permanent Colours. London, 1794.—Mémoire fur le Blanchiment des Soies fans les décruer femblables à celles connues fous le Nom de Sina et de Soies de Nankin par M. Beaume. Journ. de Phy, tom. 1. p. 375. 1793.

END OF VOL I.

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